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CONTENTS

Outlook for Energy in Last 10 Years of This Century

916B0062 Beijing ZHONGGUO NENGYUAN [ENERGY OF CHINA] in Chinese No 3, 25 Mar 91 pp 4-9, 16

[Article by the Planning Department of the Ministry of Energy Resources: "Main Problems in Development of China's Energy Resource Industry During the Seventh 5-Year Plan and Prospects for Next 10 Years"]

[Excerpts] [Passage omitted]

II. Prospects for Next 10 Years

The Eighth 5-Year Plan and Ninth 5-Year Plan are the final decade of the 20th Century, an important decade for China's achievement of the second strategic objective of attaining relative prosperity in people's living standards. The energy resource industry is facing serious challenges in finding ways to satisfy the need to attain relatively prosperous levels and provide guarantees for achieving long-term sustained, coordinated, and stable growth of our national economy. For this reason, the goal of struggle in the energy resource industry is to strive for a preliminary reversal in the energy resource shortage situation within 10 years to satisfy the needs of national economic development and improvement in the people's living standards.

Starting from this objective, the basic principle we propose for the energy resource industry is: continue to combine development with conservation. Energy resource development should be centered on electric power and have coal as its foundation, with major efforts to develop hydropower, actively develop nuclear power, and actively develop petroleum and natural gas. Strive to conserve power, oil, and coal, extend heat and power cogeneration, develop utilization of surplus heat, continue to implement the policy of replacing oil with coal, strive to increase energy resource utilization rates, and reduce environmental pollution.

Our main goals are:

A. Adapt growth rates in the energy resource industry to growth rates in the national economy.

Based on an average annual growth rate of 6 percent in our GNP over the next decade and assuming an average yearly growth rate of 7 percent in the value of industrial and agricultural output, the yearly rate of growth in primary energy resources must be about 3 percent and the yearly rate of growth in electric power must exceed 7 percent. The corresponding requirement for total output of primary energy resources is 1.2 billion tons of standard coal in 1995 and 1.4 billion tons of standard coal by the year 2000.

The components are: an increase of 400 million tons in coal output over 10 years to 1.26 billion tons in 1995 and 1.46 billion tons in 2000.

An increase of 47 million tons of oil equivalent in petroleum output over 10 years (including an additional 32 million tons of oil and 15 billion cubic meters of gas) to reach 175 million tons of oil equivalent in 1995 and 200 million tons of oil equivalent in 2000.

An increase of 87 billion kWh in hydropower to 152 billion kWh in 1995 and 210 billion kWh in 2000.

An increase of 10 billion kWh in nuclear power to 5 billion kWh in 1995 and 10 billion kWh in 2000.

An increase of 580 billion kWh in the secondary energy resource electric power to 870 billion kWh in 1995 and 1,200 billion kWh in 2000.

B. Try in every possible way to conserve energy and increase energy resource utilization rates

1. The energy conservation rate in society as a whole should be 3 percent.

2. Coal consumption to generate power in thermal power plants should reach 350 grams of standard coal/kWh in 1995, so it must be reduced by 4 to 5 grams a year during the Eighth 5-Year Plan. For this purpose, average coal consumption for power generation in newly-built power plants should be less than 330 grams of standard coal/kWh and 5,000MW of small moderate and low- pressure generators which have exceeded their service lives should be upgraded during the Eighth 5-Year Plan.

3. We should strive to reduce self-utilization rates for coal and oil fields. Strive to build 1,000MW of coal gangue power plants during the Eighth 5-Year Plan.

4. Gradually increase the proportion of electric power as a part of energy resource consumption. Concrete requirements are for one-half of new coal output to be used to generate power, so the coal used to generate power will account for 29 percent of total coal output by 1995 and 33 percent by 2000.

C. Adhere to the principle of electric power as the center and accelerate the pace of electric power development, especially hydropower

Strive to place 132,000MW in new and upgraded capacity into operation in the next 10 years, including 60,000MW during the Eighth 5-Year Plan for a net increase of 50,000MW in installed generating capacity. Plan to construct 45,000MW in large, medium, and small-scale hydropower during the next 10 years, including 27,000MW in large and medium-sized stations. The amount for the Eighth 5-Year Plan will be 10,000MW.

D. Take advantage of our abundant coal resources, accelerate the pace of coal exploration and development

We must increase coal output by 400 million tons over the next 10 years.

The scale of construction starts at unified distribution coal mines is 360 million tons and 300 million tons will

be placed into operation. Begin construction on 180 million tons and place 110 million tons into operation during the Eighth 5-Year Plan. Begin construction of 180 million tons and place 190 million tons into operation during the Ninth 5-Year Plan.

In addition, we plan to begin construction of 57 million tons of coal dressing plants and will try to place 55 million tons into operation.

E. Truly place nuclear power construction in an important position

The planned scale of construction starts over the next decade is 11,000MW, with 5,300MW going into operation. We will also strive to gain an understanding of 600MW nuclear power equipment manufacturing technology during this century and shift to domestic production of nuclear power equipment.

F. Reinforce petroleum and natural gas exploration and development

To achieve the goal of 170 million tons of petroleum and 30 billion cubic meters of natural gas by the year 2000, one urgent task is to "increase reserves and output". We plan to increase proven petroleum reserves by 4.2 billion tons within 10 years, including 2.5 billion tons in east China, 1.5 billion tons in west China, and 200 million tons offshore. Increase proven natural gas reserves by 30 billion cubic meters. We must stabilize east China and complete a strategic shift to west China, and strive to build 5 to 25 million tons in new oil regions in Xinjiang.

G. Pay attention to rural energy resources and rural electrification construction

We must actively expand grid power supplies and build medium-sized and small hydropower stations, wind energy power generation stations, and solar energy power stations in rural areas and make preliminary arrangements to build 3,500MW in medium-sized and small hydropower stations, 1,000MW in small heat and power cogeneration, coal gangue power plants, and so on, 21MW in wind energy power stations, 6MW in geothermal power generation, and 5MW in solar power generation during the Eighth 5-Year Plan.

H. Rely on scientific and technical progress, increase economic benefits and labor productivity, reduce environmental pollution

Rely on S&T progress to build several large projects:

1. We must build the 16,780MW Three Gorges, 4,000MW Longtan, 3,000MW Ertan, and other hydropower stations and build large capacity pumped-storage power stations to solve grid peak regulation problems.

2. We must build 13 thermal power plants of about 3,000MW.

3. Build 2 four-reactor X 600MW and 2 two-reactor X 1,000MW nuclear power plants.

4. Form a 500 kV network for all grids in China, consider the issue of grid interconnection over large regions, and do research on ultra-high voltage grade power grids.

5. In the area of coal, build the 60 million ton Shenmu Dongsheng and the 15 to 20 million ton Jungar, Huolinhe, Ansuoling, Antaibao, Jincheng, and other mining regions, import and develop 10,000 ton daily output fully-mechanized mining equipment.

6. Develop new oil and gas prospecting techniques, gain an understanding of technology for developing oil and gas prospecting in deserts, offshore, and at sea, make breakthroughs in key technical problems with oil transmission pipeline construction and marine oil and gas collection and transmission technologies.

Rely on S&T and raise management levels to continually increase economic benefits and labor productivity:

1. Full-staff labor productivity for coal should reach 2 tons/manshift by 2000, an average yearly increase of 5 percent.

2. The degree of coal mine mechanization should be increased from 61 percent in 1989 to 84 percent in 2000.

3. Full-staff labor productivity in the electric power industry should be 1 percent greater than during the Seventh 5-Year Plan for yearly growth of 5 percent.

4. Coal consumed for power generation should be reduced by an average of 4 to 5 grams per year.

5. Shorten construction schedules. Thermal power plants of a scale larger than 600MW should have construction schedules of 24 to 30 months from the time that main project construction begins until the first generator begins operating. It should take 2 to 4 years from the time the flow is diverted until the first generator begins operation for large and medium-sized hydropower stations. Coal mines of the 1 million ton grade should have construction schedules of 4 years from the time that main project construction begins until they begin operating.

We believe that if we just resolutely foster the advantages of the socialist system, adhere to reform and opening up, and resolutely rely on S&T progress and scientific management, we will certainly be able to achieve these objectives through 10 years of arduous efforts and the energy resource industry will leap up to a new stage and welcome the arrival of the 20th Century [as published].

Tremendous Growth Seen for Energy Industry in 8th FYP

916B0063B Xining QINGHAI RIBAO in Chinese 12 Apr 91 p 4

[Article: "China's Energy Resource Industry Will Grow Substantially During Eighth 5-Year Plan"]

[Text] China's energy resource industry will grow substantially during the Eighth 5-Year Plan. At the same time, the energy resource industry will adhere to the principle of combining development and conservation and place conservation in a prominent status.

According to the plan decided upon in the "10-Year Plan and Eighth 5-Year Plan Program for Development of the National Economy and Society", total output of primary energy resources in China will reach 1.172 billion tons of standard coal in 1995, up by 132 million tons over 1990 and an average yearly increase of 2.4 percent. Over the next 5 years, total conservation and reduced utilization of energy resources in China will be 100 million tons of standard coal.

By 1995, planned coal output in China will be 1.23 billion tons, up by 150 million tons over 1990, and we will continue building several projects now under construction like Huolinhe, Yimin, Yuanbaoshan, Jungar, and other large strip mines in Inner Mongolia, construct the Datong mining region and Shenfu Dongsheng mining region, the Tiefa and Shuangyashan mining regions in northeast China, Yanzhou, Huainan, and Yongcheng mining regions in east and southcentral China, and others. We will begin construction of Huangling mining region in Shaanxi, Lingwu mining region in Ningxia, Pingshuo Anjialing strip mine in Shanxi, and other projects.

During the Eighth 5-Year Plan, electric power construction in China will implement the principle of adapting to local conditions, combined development of hydropower and thermal power, and appropriate development of nuclear power. Over the 5-year period, the focus will be on construction of Ertan in Sichuan, Yantan in Guangxi, Manwan in Yunnan, Geheyan in Hubei, Wuqiangxi in Hunan, Yarzhoyum Co in Tibet, Lijia Gorge in Qinghai, and other hydropower stations and on Yimin, Yuanbaoshan, Suizhong, Shanghai Waigaoqiao, Changshu, and other thermal power plants and the second phase of the Qinshan nuclear power project. By 1995, total power output in China will reach 810 billion kWh, an increase of 192 billion kWh over 1990.

The development principle for the petroleum industry during the Eighth 5-Year Plan is stabilizing east China and developing west China. In 1995, state arrangements call for crude oil output of 145 million tons (including 5 million tons from offshore). Natural gas output will be 20 billion cubic meters.

10-Year Outlook for Power Industry Summarized

916B0071B Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 10 May 91 p 1

[Article by reporter Li Gang [2621 6921]: "The Electric Power Industry Faces Heavy Tasks and a Long Road in Doubling Output Within the Next 10 Years, Ministry of Energy Resources Calls S&T Progress Onto the Stage Again"]

[Text] To ensure that China's electric power industry fulfills its strategic tasks of an installed generating capacity of 240,000MW and yearly power output of 1,200 billion kWh by the end of this century, the Ministry of Energy Resources has called S&T progress to the stage again to move technical levels in important realms of the electric power industry up to international levels of the early 1980's. Based on this, it has determined the goals for S&T progress in the electric power industry over the next 10 years and tasks for the Eighth 5-Year Plan.

The primary objectives for S&T development in the electric power industry over the next 10 years are: in the area of thermal power, adopt high parameter, large capacity thermal power generators; use advanced technology to provide water to power plants, conserve water, haul coal, eliminate ash, prevent environmental pollution, and so on. By the end of this century, the average amount of coal consumed to generate power at all of China's thermal power plants should be reduced to 380 g/kWh, generator availability rates should reach 78 percent, and the amount of water consumed at power plants which employ cooling towers should be less than 1 ton/second per 1,000MW of capacity. Make good preparations for using supercritical generators, super- supercritical generators, generators with single unit capacities at the 1,000MW grade, and coal gasification combined cycle power generation technology

In the area of hydropower, we should focus on construction of several large and medium-sized key hydropower stations with good regulation properties and gain an understanding of capacity increases and upgrading to expand functions at old hydropower stations and key technologies at pumped-storage power stations. Develop geophysical prospecting, remote sensing, and satellite applications technology, modernize survey programs, and shorten construction schedules. Make good preparations for construction of huge hydropower stations and the associated technology, and for high-head large-capacity pumped-storage power stations.

In the area of nuclear power, focus on nuclear power construction, installation, debugging, operation, and personnel training, track and try to apply the world's newest technology.

In the area of power grids, improve line design and construction technology for 500 kV power transmission and transformation equipment, gain an understanding of positive and negative 500 kV DC power transmission

technology, study new types of over-voltage limitation technology, and improve on-line monitoring technology for power transmission and transformation equipment. By the end of this century, we should complete a graded data collection, monitoring, and control system to satisfy grid dispatching needs. Complete telephone, digital, facsimile, and graphics information comprehensive digital communications networks. Make good technical preparations for 1,000 kV-grade super-high voltage power transmission technology and the formation of a nationally integrated grid.

The tasks determined for the Eighth 5-Year Plan by the Ministry of Energy Resources include focusing on key technology in electric power production and construction, and undertaking three-level attacks on key S&T problems at the state, ministry, and basic grid and province levels. Adopt a series of encouragement measures to reinforce extension and application of new technology and new achievements, rely on policy measures to focus on technical upgrading in enterprises. Integrate technology and trade, reinforce international exchanges. Strengthen technical supervision and perfect reform of the S&T system.

Suggestions for Accelerating Development of the Energy Industry

916B0066 Beijing ZHONGGUO NENGYUAN [ENERGY OF CHINA] in Chinese No 4, 25 Apr 91; No 5, 25 May 91

[Article: "Suggestions on Ways and Means To Accelerate Development of the Energy Resource Industry, Proposals From 1st Full Session of Ministry of Energy Resources Senior Consulting Committee Members"; manuscript provided by Zhang Jiwu [1728 4949 2976]]

[Part I; No 4, 25 Apr 91, pp 1-4]

[Text] During the National Energy Resource Work Conference, minister Huang Yicheng [7806 3015 6134] chaired the first meeting of the Ministry of Energy Resources senior consulting committee members. The meeting heard views and suggestions from senior consulting committee members concerning development of the energy resource industry. We are now publishing summaries of some of their views and suggestions.

I. Focus on Research and Development for China's Two Energy Resource Base Areas

Lei Shuxuan [7191 2885 5503]: Over the past 20 to 30 years, the basic configuration of China's energy resources has been an energy resource base area in north China centered on Shanxi and a southwest hydropower energy resource base area in southwest China centered on the Jinsha Jiang and including lignite. The north China base area extends from north to south along the sea coast while the southwest base area runs along the banks of the Chang Jiang and into southern China. Central China has become the point of intersection of these two extensions. We should use this configuration as the focus to study China's energy resource deployments from 2000 to 2020 including how to deploy power grids and questions related to transportation. I suggest that the Ministry of Energy Resources organize the related areas for separate research.

Zhu Shiwei [2612 1102 0251]: Besides the energy resource base area centered on Shanxi, China has another energy resource base area, the southwest China hydropower energy resource base area. We should start early with research and development. There are three programs: readjust the industrial structure and develop high energy consuming products in southwest China, use high-voltage power transmission lines (DC power transmission is economical) to transmit power to east China, and consider exporting hydropower from southwest China.

II. Energy Resource Structure Issues in the Eighth 5-Year Plan and Next 10 Years

Jiang Zhaozu [5592 0340 4371]: A balance in primary energy resources by the year 2000 requires consideration both of demand and possibilities in an effort to establish primary energy resource supplies on a reliable foundation and leave no major shortages. Calculations based on preliminary indices for energy resource development planned by the State Planning Commission indicate that total output of primary energy resources in 2000 will be just 310 million tons of standard coal more than in 1990, which is 93 million tons less than the amount of increase over the 10-year period from 1980 to 1990 and even 17 million tons less than the increase from 1970 to 1980. I suggest that further research is needed to determine if this arrangement can meet the requirements of national economic development.

The scale of actual construction starts at unified distribution coal mines during the Seventh 5-Year Plan was 90 million tons smaller than originally planned, the capacity placed into operation was 56 million tons less, and the amount carried over into the Eighth 5-Year Plan was 37 million tons less, which will directly affect reserve strengths in coal industry development over the next decade. Over the next 10 years, China will complete several key large enterprises which will create higher requirements both in quantity and quality for coal demand. This requires concentration of forces and a corresponding acceleration of unified distribution coal mine construction to increase the proportion of output from unified distribution coal mines.

Only 17.7 percent of our coal was dressed in 1990, which means that not only did we fail to increase the proportion compared to 1980 but actually allowed it to decrease by 0.17 percent. This increases the pressures on transportation, increases environmental pollution, and results in poor economic results in enterprises. I suggest that we organize forces for special survey research on this problem to propose policies and measures to solve it and increase the proportion being washed.

To effectively utilize China's limited petroleum resources, we should continuing adhering to the policy of reducing the burning of oil over the next decade. We burned 17 million tons of oil to generate electricity in 1990, which is equivalent to burning half of the output from Shengli oil field during 1990. Accelerating the pace of substituting coal for oil will help alleviate the shortage of petroleum supplies and increase the economic results from resource utilization.

Zhu Yajie [2612 0068 2638], Wang Dexi [3076 1795 3556], Ouyang Yu [2962 7122 0056]: Coal and petroleum are similar in that both are a fuel as well as a raw material, so it is a real pity to burn them directly. We have already achieved comprehensive utilization of petroleum to a considerable extent with obvious benefits. We still burn most of our coal, however. At present, coal accounts for 76 percent of our primary energy resources, so the more coal we burn the greater the waste and the more serious the pollution. If we assume the carbon dioxide from burning natural gas to be 100 percent, then burning coal is 200 percent and burning petroleum is 127 percent.

In the future, we should reduce the direct burning of coal as an ultimate energy resource and increase the proportion that is converted to electric power, and we should extend circulating fluidized bed or pressurized fluidized bed, coal gasification combined cycle, and other technology to increase the utilization results of coal heat energy and reduce pollution. We also should make major efforts to develop the coal chemical industry.

We should start the Eighth 5-Year Plan by readjusting the energy resource structure. At present, we should concentrate financial forces to increase development of petroleum and natural gas, and we should take into consideration China's rather substantial easily-developable hydropower resources and allow hydropower to play a leading role in readjustment of the energy resource structure in the short term. Looking toward the longer term, we should rely primarily on nuclear power to compensate for electric power shortages. Nuclear power will play a major role in China's third-step strategic objectives for developing our national economy. As a result, we should begin early in acknowledging that nuclear power development should be viewed as a strategic objective and do more preparatory work, such as showing greater concern and support for construction of 600MW nuclear power plants to make them more mature earlier, reduce construction costs, and so on to avoid having inadequate measures when we do face development of nuclear power on a huge scale.

For China's development of nuclear power, whether we are discussing guaranteed safe power generation or guaranteed nuclear power plant safety, we must perfect equipment and reinforce management. We are now adopting measures in these two areas.

We should further develop nuclear power and transform the energy resource structure. It will take at least 3 more years to add 600MW at Qinshan nuclear power plant, so I suggest that we use this time to begin two 300MW nuclear power [generators]. There would be problems at present in relying totally on local areas to develop nuclear power, so we should rely mainly on state support.

III. Focus on Research and Planning Work To Integrate a National Grid, Develop a Variety of Joint Operations and Integration

Xu Bowen [1776 0590 2429]: Grids have been weak for many years and the problem has still not been solved. Quadrupling electric power output by the end of this century will also require a several-fold increase in grid construction and new grids will certainly be larger than older grids. We cannot do as we did in the past, first working to build power sources and then connecting them to the electric power system to form grids naturally. I feel that the state should organize large-scale research work involving a project to study a network structure with the objective of developing a nationally-integrated grid. This is question of strategic deployments in the electric power industry as well as a question of internal relationships. The future economy and effectiveness of energy resource regulation would depend on how well grids are operated. The ideology of small power plants and small grids cannot be carried into the 1990's. In the future, primary power plants must be connected to primary grids. Circuits cannot simply build single loops, but must build double loops. After high-voltage grids are completed, low-voltage grids must be disconnected, and so on. We should start working now to study and plan a national grid. Only after the design of the framework for a national grid is prepared will the electric power industry have goals and planning qualities. First, we must reinforce all large regional grids. To integrate a large regional grid with another large regional grid, we first must select the most advantageous and simplest integration pattern. This means we must achieve the economic benefits of grid integration and guarantee that all grids are capable of fighting for themselves. Energy experts in the United States feel that China now has an extremely good opportunity to make power transmission choices and that research should be done and decisions made soon concerning whether we adopt synchronous (AC) or asynchronous (DC) arrangements.

We must develop multi-industry integration. Joint administration of coal and power should gradually move toward integration of coal and power. Development of hydropower should be integrated with local development of high energy consuming products which can enable no transmission of power or the least transmission of power to outside areas.

IV. Some Issues in Electric Power Industry Development

Lei Shuquan: "An energy resource development strategy centered on electric power" is very important for future

energy resource development. It has an extremely broad content because it does not have the narrow definition of "electric power". Instead, it is a comprehensive reflection of an advanced force of production. I propose that the Ministry of Energy Resources organize several discussions to further enrich the content of this strategic ideology to guide future work.

Wen Kechang [3306 0344 2490]: Development of the electric power industry should solve these problems in its development plans:

1. We must deal properly with internal proportions in the electric power industry. One thing is to deal properly with the ratio between grid capacity and power source capacity. The capacity of a grid should be higher than power source capacity, but at present grid capacities lag behind power source capacities. A second thing is to deal properly with the ratio between active power and reactive power in grids. At present, they have insufficient reactivity which prevents guaranteed voltage quality. Third, we should focus on urban grid upgrading and matching. Urban power grids are a weak link at the present time. If this problem is not solved, we cannot foster the comprehensive capacity of grids.

2. The question of scale economies in the electric power industry. To develop large generators and large grids, everyone must now unify understandings. We cannot use provinces as the basis for grid construction. There must be unified management of grids.

3. Raising capital through multiple channels to develop power plays a major role in the electric power industry, but it also causes several problems which require summarization and perfection. Raising capital to develop power requires both grid construction and power source management, and some can implement separation of ownership rights and administrative rights.

4. The question of equipment renewal in the electric power industry. Several retired generators should be returned to use. Some can be converted to heat supplies, some can be used for peak regulation, and some can be used to develop reactivity.

V. Be Concerned With Reliance on Science and Technology for Energy Conservation

Deng Shoupeng [6772 1108 7720]: At present, to produce $1,000 in GNP, converted to primary energy resources, China requires about 3 tons of standard coal, the United States requires 0.76 tons, and Japan requires only 0.35 tons. Converted to secondary energy resources, China consumes 1,780 kWh of power while the United States consumes about 600 kWh. The substantial potential for energy conservation is obvious. There is also great potential for electric power utilization in China. According to incomplete statistics, each year power plants can conserve 16 billion kWh of power from their own power equipment line losses and grid losses. Fans and pumps can conserve 14.5 billion kWh and power use for lighting can conserve 13 billion kWh of power. Other areas (electric locomotives, high-frequency heating ovens, electric steel furnaces, industrial kilns, DC welders, etc.) can conserve 10.5 billion kWh of power. The total conservation of power for these things would be 54 billion kWh.

Energy conservation must rely on reinforced management and readjustment of the industry and product structure. Even more important is the need to rely on S&T progress. I suggest that extension and application of electric power and electronics technology serve as an important energy conservation measure in China. China's units that are involved in electric power and electronics technology R&D and in components and equipment unit production have already attained an initial scale in Beijing, Shanghai, Xi'an, northwest China, southwest China, and other regions. Our imported giant transistor (GTR) and switchable transistor (GTO) production lines have already been placed into operation. The converter equipment used in electrochemistry, electric power and electronic equipment used for AC/DC drives, power source, excitation, and speed governing equipment for various uses, and other things have already entered the market. I propose that the State Planning Commission and Ministry of Energy Resources make arrangements in the Eighth 5-Year Plan and 10-year plan to make full utilization of electric power and electronic technology a primary measure in China's energy conservation work and implement it.

Wang Dexi: Coal is China's main energy resource at the present time and increasing the heat energy utilization rate of coal is the focus of energy conservation. There are three measures. One is to increase the thermal efficiency of coal as much as possible, which requires analysis using the first law of thermodynamics. The second is to increase heat conversion rates as much as possible, which requires analysis of effective power using the second law of thermodynamics. The third is focusing on comprehensive utilization of coal and implementing various cogeneration programs including the "triple combined supplies" by using coal to generate electricity, supply gas, and produce chemical industry products, and "triple combined supplies" by using coal for power generation, heating, and cooling. In regard to various programs for comprehensive utilization of coal, we should use thermal economics analysis as a foundation for selecting the best for R&D. The Ministry of Energy Resources should actively participate in and support projects that should be done during the Eighth 5-Year Plan.

VI. Developing Coal Gasification Combined Cycle Power Generation, Storage Battery Energy Storage and Regulation, and Other Questions

Lai Jian [6351 1017]: Coal is the primary fuel used for thermal power generation in China. There are three main programs that have been the subject of the greatest amount of debate among China's S&T circles in regard to the type of technical program that should be selected to turn them into high performance and clean coal-fired

power plants: 1) Raising temperatures and pressures to super-criticality or even super-super-criticality. 2) Circulating fluidized beds or pressurized fluidized beds. 3) Coal gasification combined cycles. Comparison of these three programs indicates that coal gasification combined cycle power generation is the best choice. Coal gasification combined cycle power generation involves first gasifying coal, burning the coal gas in a gas-burning turbine to generate power, using the exhaust gas from the gas-burning turbine for a surplus heat boiler to generate steam and then transmitting the steam to a steam turbine to generate power. Its main advantages are high efficiency, complete pollution prevention measures, effective and conservative use of water, reduction in the land area taken up by a power plant, ease of use for power plant load regulation, comprehensive utilization of energy, and relatively high economic and social benefits. Coal gasification combined cycle power generation has been fermenting in China for many years but it has always been put off, so I propose that decision making departments decide soon to begin industrial demonstration projects and then extend it after gaining experience.

Building pumped-storage power stations for use in electric power peak regulation is an important measure, and we can use compressed gas energy storage and storage battery energy storage. Storage battery energy storage is feasible given present conditions in China and is especially appropriate for areas which lack hydropower. They can also be used with lead-acid batteries used in conventional submarines when they are travelling underwater. There are power plants in foreign countries as big as 10MW which use storage batteries for energy storage. When China gets started, we should begin with several 100 kW and recommend them for trial use in enterprises, large hotels, and clusters of structures to replace reserve diesel power generators, which is very appropriate. I suggest that development of storage battery energy storage should be included in energy resource plans.

[Part II; No 5, 25 May 91 pp 1-3]

[Text]

I. Two Medium and Short-Term Strategic Issues in Energy Resources

Huang Zhijie [7806 1807 2638]: There are many strategic energy resource issues that require discussion in China's economic development process. I feel that two questions deserve attention in the short term.

1. Be concerned with the problem of the possible appearance of serious energy shortages.

In the current weak market situation, coal overstocks and improved energy resource supplies have appeared. As soon as the economy recovers and growth accelerates, comprehensive shortages of coal, power, and oil may reappear. Arrangements in the Eighth 5-Year Plan and Ninth 5-Year Plan call for average yearly economic growth of 6 percent and this figure will usually be exceeded in normal years. The average increase in amounts arranged, however, is 2.5 percent for coal, 6 percent for electric power, and 1 percent for petroleum. Moreover, one-half of the coal will depend on taking full advantage of local coal mines and township and town coal mines. The elasticity coefficient of our energy resource consumption is less than 0.5 and we hope of use energy conservation for the insufficient portion. Energy prices are relatively low in China and the economic returns to energy conservation are rather poor, so we are unwilling to expend much effort on energy conservation and it is quite difficult with an energy resource elasticity coefficient below 0.5. The elasticity coefficient of energy consumption during the past 10 years was below 0.5 and the new prices set for new products that were developed in large amounts which did not completely deduct product price increase factors play a role that cannot be neglected. Thus, we cannot be blindly optimistic about having an energy elasticity coefficient below 0.5 during the previous decade. Instead, we must do propaganda concerning the possible appearance of energy resource shortages, study increases in energy inputs, and promote social energy conservation.

2. Severe shortages of superior quality energy resources may appear

As our economy grows and people's living standards rise, growing numbers of residents will want to use convenient, clean, and time-saving superior quality energy resources—electric power and coal gas—instead of coal. This is a normal, rational, and inevitable development trend in urban energy use patterns. There has been substantial growth in urban coal gas and civilian electricity consumption over the past 10 years but we still cannot satisfy the people's demands. Coal as a proportion of household energy consumption decreased from 90.2 percent in 1980 to 84.3 percent in 1990 while gas fuels increased from 1.85 percent to 3.3 percent and electric power rose from 4.5 percent to 8.8 percent. To meet the requirements of people's living standards, conserve energy, and improve the environment, in the future we must accelerate the development of coal gas, centralized heating, and household electricity use. However, China has not had a sufficient understanding of or concern for the development of a shift to coal gas, central heating, and household electricity use in urban areas for a long time. This problem must be solved and we must adopt measures to meet people's demands for superior quality energy resources in their lives.

II. The Question of Reinforcing Oil and Gas Exploration

Zou Ming [6760 2494]: The current situation in China's petroleum industry is serious. The main thing is a loss of coordination in our petroleum resource structure and severely inadequate proven petroleum reserves which cannot meet the demand for increased petroleum output. Since 1988, yearly crude oil output has hovered around 137 million tons and new additions to reserves each year actually have not compensated for the amounts extracted during those years. Natural gas output has

fluctuated without increasing for 10 years. Natural gas output was 14.5 billion cubic meters in 1979 and 14.7 billion cubic meters in 1990.

"Reinforce oil and gas exploration, increase reserves" is a requirement set forth quite some time ago by the state and energy resource departments but it actually has never been implemented. We must overcome short-term behavior in our ideology which only looks at immediate production. I suggest that we adopt these measures:

1. We must do all the work required for sufficient oil and gas exploration. Survey and design have already decided that strata must be assigned as hard indices. Capital for surveying must be kept in separate accounts and not shifted to other purposes.

2. Copy the method of everyone developing electric power, advocate and encourage local areas to raise capital for oil and gas resource exploration and development. Mobilize all business units in petroleum and mineral departments, reinforce oil and gas prospecting forces. Formulate reward methods for discovering oil and gas reserves.

3. Accelerate opening up to the outside world in exploration and development of East China Sea petroleum.

4. Immediately readjust oil and gas prices, gradually eliminate the "dual- track system" for oil prices.

Zhu Yajie [2612 0068 2638]: Petroleum has already become a strategic problem and we must accelerate oil and gas development. In the more optimistic view, Tarim Basin has very large oil reserves but there is some disagreement over the actual amount. The main problem is that insufficient work has been done, but the overall potential oil reserves are rather large. We can develop them before the year 2000 and may be able to obtain as much as one or two Daqing [oil fields] by 2020. Given present geological, financial, and material conditions, progress has been very slow, so we should borrow experiences in foreign countries, open up internationally, and attract foreign investments or engage in cooperative development. It will not be possible to develop such large oil deposits without economic and political strengths as reserve strengths.

III. Accelerate Development of Hydropower

Zhang Xianhong [1728 2009 1347]: The biggest problem in China's energy resource development is the development of hydropower. Hydropower is the cheapest and cleanest energy resource and should be given preference in development. The Chinese government's policies concerning hydropower have undergone many changes but it has never been placed in a primary position. The results of implementation show that many of China's provinces have not paid sufficient attention to hydropower and have several misunderstandings regarding the comprehensive quality and economic value of hydropower, or some departments have used distorted energy resource prices in attempts to build thermal power plants which lack coal supplies and are unwilling to develop their own hydropower stations. Hydropower is a renewable energy resource. Like solar power, it is both a primary and a secondary energy resource at the same time, but it has been included among secondary energy resources for a long time and has not enjoyed preferential policies like those for coal and electric power development. Hydropower is now listed as a primary energy resource, but policies in areas like interest rates on loans, loan repayment schedules, requisition of land-use taxes, and so on have still not been implemented. Although hydropower has developed some in the past several years, the proportion it comprises of all electric power has declined from 30.4 percent in 1980 to 26 percent in 1990.

China has 670,000MW of hydropower, 370,000MW of it developable. This includes 150,000MW with better conditions which can be developed in the near term, which is equivalent to saving 600 million tons and 300 million tons of coal each year. Thus, we must resolutely adhere to the principle of "preferential development of hydropower", increase and provide preferential guarantees for hydropower funds, and request preferential policies for hydropower development from the state. The Ministry of Energy Resources has made positive arrangements for hydropower during the Eighth 5-Year Plan and the next 10 years, and the question is their implementation. At the same time, hydropower construction must respect the principle of "cascade development, building tap reservoirs first" and focus on all forms of preparatory work.

IV. Long-Term Coal Development plans and Rectification of Mining and Extraction Procedures

Chen Bingqiang [7115 3521 1730]: 1. It has now been determined that China's coal output in the year 2000 will be 1.46 billion tons. The proposal in 1985 was 1.2 billion tons but was later increased to 1.4 billion tons. The 1.4 billion ton figure was suggested because of demand but our foundation is weak and it now appears there may be even more problems. The original plan for 1.2 billion tons used development of open-cut mining as an important measure but the actual pace of strip mine development over the past several years has been slow. The original plans for capital construction during the Seventh 5-Year Plan were not completed and there were no reserve strengths. It is possible that no new mines will go into operation around 1993. It has been proposed that at that time, local coal mining should focus on 100 coal-producing counties and upgrading in some important mines but many measures have still not been implemented. Now, however, a plan for 1.46 billion tons has been proposed, up more than 60 million tons from the original plan. I fear that coal output will not increase and we will fail in a major national matter.

2. Two transitions must be achieved in the coal industry before 2015.

One is a strategic shift toward the "three wests" (Shanxi, Shaanxi, and western Inner Mongolia), extending the outward shipment of Shanxi coal to the "three wests", and corresponding solutions to water source and environmental protection problems. We will have to ship 450 million tons of coal out of this region in the year 2000. This must acknowledged by society and by the state, and the corresponding measures must be adopted.

The second transition includes abandoning 30 mining regions within 30 years, including 26 mining regions in coal-short areas of east China. An additional group of mines will have to abandoned. Moving these abandoned mines will involve 1 million personnel. All these problems deserve our attention.

3. We must solve the problem of internal coordination of coal industry development, which includes the ratio between unified distribution coal mines and local mines and the question of coordinated development of processing and dressing, strip mines and shaft mines, production, scientific research, education, construction, geology, manufacturing, and other areas.

4. The question of procedures for improvement and rectification in the mining industry. Coal mining procedures are chaotic at present. Indiscriminate extraction and wanton excavation in small coal pits has created substantial losses each year, including losses created by unified distribution coal mines. Improvement and rectification of mining procedures should become the order of the day in Ministry of Energy Resources work. How do we begin using rectification to provide proper roles for and achieve healthy development of unified distribution, local state-run, and township and town coal mines? There are two routes. One is unconditional shutdowns of small shafts which endanger safety at large mines. The other is to propose that the State Council reaffirm that local governments must compensate for major losses due to accidents that are caused by small mines. The State Council made this sort of decision following accidents at small coal pits in Huainan, with good results.

V. Suggestions and Views Concerning Increased Strip Mine Extraction

Peng Shiji [1756 0013 3444]: Internationally, increased output has depended on large open-cut mines. China now has plans to develop strip mining, and I feel we should absorb historical experience and lessons. Since the nation was founded, the development of open-cut coal mines has moved with fits and starts, for many reasons. One is that there are clear technical policies but we have no specialized personnel staffs to study problems in strip mining. The second is that we did not open up sufficiently during a previous period and our strip mining equipment was not satisfactory. We have consistently used a railway transport and extraction arrangement, so capital construction has involved a great deal of engineering, large investments, and long construction schedules. The third is that coal prices are low, so larger output also means larger losses.

Some proposals: 1) A rolling scale should be used to develop strip mines. We should not begin all at once at a scale that is too large, but should instead do things gradually. 2) We should pay attention to reforming extraction procedures. We have worked on a few small strip mines like Heibaoshan and Yilan in Heilongjiang, where expanding from the original 300,000 tons to 900,000 tons would have taken 33 million yuan, but we were able to accomplish this with 27 million yuan after changing extraction procedures. Our school did some research. We reformed extraction procedures and work line lengths at nine mines and saved 500 million yuan in investments. We must also change our design ideology of single questions and not use truck transport techniques in all cases. There were special conditions for using truck haulage at Antaibao, but if we use truck haulage for all of China's strip mines it would be like substituting oil for coal. Adopting comprehensive techniques is a common trend in world strip mining and we should also take this route. 3) We must focus on reform of design ideology and design staff construction.

VI. Use Technical Measures To Maintain Stable Output at Daqing Oil Field

Wang Demin: [3076 1795 3046]: Daqing oil field has had stable output for 15 years, but the water content reached 80 percent in 1991, which means that it must extract 4 tons water for every ton of oil. At this rate, stable output has now become difficult. It is internationally recognized that an oil stratum must be 0.5 meters thick before it is considered to be reserves. From 1991 to 1995, we will be extracting from strata less than 0.2 meters thick. Some say that these are not oil strata since they no longer have the color of oil, which is equivalent to extracting coal gangue in coal mines. Using existing technology, Daqing oil field can maintain stable output to 1995.

What will we do after 1995? We cannot just inject water, but instead must add polyacrylic ammonia to make the water denser. Making the water denser can push out the oil. This method can raise the extraction rate by 12 to 13 percent up to 52 to 53 percent, so the benefits are very good. 1) Each ton of polymer injected can increase the crude oil by 150 to 200 tons. Daqing has 2.78 billion tons of reserves suitable for using this method, so increasing extraction rates is equivalent to adding 350 million tons of recoverable reserves, which equals 1.4 billion tons in geological reserves. If Daqing only finds 40 million tons of geological reserves a year, this would equal 30 to 40 years of discoveries. If China as a whole finds 350 million tons of geological reserves a year, this would be equivalent to 2 to 3 years of discoveries. Discovering 1.4 billion tons of geological reserves at Daqing would cost 20 billion yuan but injecting polyacrylic ammonia would cost just 1 billion yuan, which is just one-twentieth of the investment. 2) Extracting 100 million tons of geological reserves from the area surrounding Daqing would require 18 billion yuan in capital construction investments but injecting polymers would only cost 5 billion yuan, which is one-third the investment. 3) Building 1

million tons in production capacity in the region surrounding Daqing would cost over 4 billion yuan including the cost of prospecting. Using polymers would only cost 800 million yuan, or one-fifth as much. 4) Using this method to extract 350 million tons of recoverable reserves would require the extraction of 4.1 billion cubic meters less of water, use 75 billion kWh less of electric power, and save 16.7 billion yuan in costs. 5) Preliminary calculations show that injecting 50,000 tons of polyacrylic ammonia each year could increase petroleum output at Daqing oil field by 10 million tons compared to not injecting and stabilize output for over 30 years up to around 2027. This is long-term behavior. This project has already been submitted to the State Planning Commission and I hope that the Ministry of Energy Resources will push for approval of this project.

Ordos Energy Base Taking Shape

Ih Ju League

916B0071A Beijing RENMIN RIBAO in Chinese 29 May 91 p 2

[Article by Chen Qihou [7115 0796 0624], CPC Committee secretary of Ih Ju League, Inner Mongolia and Hu Zhian [0729 3112 1344], mayor of Ih Ju League: "An Energy Resource Base Area Is Now Arising at Ordos"]

[Text] The "Proposal" passed by the 7th Plenum of the 13th CPC Central Committee pointed out in two places that we must make major efforts to reinforce construction of the energy resource base area in the western part of Inner Mongolia. The western part of Inner Mongolia referred to here is our Ih Ju League. Since 1990, Jiang Zeming, Li Peng, Qiao Shi, Song Ping, and other leading comrades in the CPC Central Committee have come to Ih Ju League to inspect and guide work. Cadres and the masses of all nationalities throughout Ih Ju League are now making concerted efforts and uniting in struggle and a new situation in construction of China's energy resource base area is taking shape.

Ih Ju League is located on the Ordos Plateau and is surrounded on the west, north, and east by the winding Huang He and borders on Shanxi and Shaanxi Provinces and Ningxia Hui Autonomous Region. This was the ancient village of "Hetao Man" and is the site of a generation of Tianjiao Chengji Sihanqin tombs.

Ih Ju League has large coal reserves with good quality that are easily extractable. It now has 105 billion tons of proven extractable coal reserves, equal to one-seventh of China's total proven reserves. After arriving at Ih Ju League, the Natural Resources Investigation Commission of the Chinese Academy of Sciences called the area of Ih Ju League along the Huang He the "golden belt" of the Huang He. As the strategic focus of state energy resource construction has shifted westward, the doors of the energy resource treasurehouse in Ih Ju League have been opened and the dreams and desires the people of Ih Ju League have had for many years are becoming a reality. During the Seventh 5-Year Plan and Eighth 5-Year Plan, three key state construction projects were placed in Ih Ju League. At Dongsheng coal field, developed by the state Huaneng Group, the coal it produces is so clean that it does not require dressing to be used in industrial production. It can also be turned into coal-water slurry to replace certain petroleum products. It is now one of China's main coal export varieties. The dedicated Bao-Shen (Baotou-Shaanxi Shenmu Daliuta) railroad for hauling coal has now opened the entire line and begun hauling coal. Dongsheng coal field will form a yearly production capacity of 15 million tons by 1995. Another closely related large coal field, Jungar coal field, has been included by the State Council among 27 energy resource projects for new construction and expansion. The coal field covers an area of about 1,022 square kilometers and has coal seams as much as 33.65 meters thick. Calculated at a yearly output of 12 million tons of raw coal, it could be mined for more than a century.

Supporting state construction, invigorating local economies, using key state construction to promote the development of local economies, and using development of local economies to promote key state construction have become new topics for the economy of Ih Ju League. We must seize this historic opportunity and take the route of resources—energy—finances—prosperity to invigorate Ih Ju League. In actual work, we must handle two relationships properly, meaning that we must deal correctly with the relationships among the state, local areas and the masses, and deal correctly with the relationships between long-term interests and immediate benefits. We must do good service work in five areas: 1) land requisition, demolition, and moving work, implement preferential policies in land requisition work, and turn on a green light for demolition and moving to avoid problems in construction schedules; 2) major efforts to develop the construction materials industry, obtain materials locally and actively coordinate to guarantee the brick, tile, sand, stone, white lime, cement, and other construction materials needed for key state project construction, reduce haulage, and lower costs; 3) develop tertiary industry, focus on key project construction, develop the food and beverage, commerce, repair, and other service industries; 4) push forward with non-staple food product base area construction and focus on "food basket projects". All of Ih Ju League should build ten large base areas in a planned and gradual manner for vegetables, pigs, dairy (and beef) cattle, poultry and eggs, fruit, aquatic products, and so on to ensure supplies of non-staple food products for key projects; 5) Reinforce town construction in mining regions and mining region management.

The state doing key construction in our nationality region is an important decision for developing and bringing prosperity to our nationality's economy. We must seize this opportunity, take aim at strategic objectives and key construction projects, and work hard for 10 years to push our economy forward and attain the goal of more than quadrupling our GNP on the basis of 1980 and achieving a relatively well-off living standard for our

people by the end of this century. We must adhere to two things to achieve this magnificent objective. First, we must adhere to reform and opening up, open up our ideology, and overcome the ideology of closing doors to do construction. Policies must be open and we must formulate good policies that are more open, more preferential, and more attractive to make Ih Ju League's preferential policies as attractive as Ih Ju's abundant resources. Our work must open up and train in the "spirit of Yugong" [the Foolish Old Man who removed the mountain] of building and enterprise through arduous effort and opening up to advance. For personnel, we must develop, train, and import a group of skilled people who understand technology and know how to manage. Second, we must resolutely unite and fight to advance. Unity in the fight to advance is the basic guarantee for development of Ih Ju's resources and construction of a state energy resource base area.

Building Ordos into a major energy resource base area in the western part of China is an ardent desire of the party and state as well as a common aspiration of the 1 million people of all nationalities in Ih Ju League. We must lead the 1 million cadres and masses of all nationalities in earnestly adhering to the spirit of the 7th Plenum of the 13th CPC Central Committee, actively support key state construction, and lead and promote development and prosperity of our nationality economy.

Mine, Power Plant Construction

916B0063C Beijing RENMIN RIBAO HAIWAI BAN in Chinese 24 Apr 91 p 3

[Article by reporter Qu Zhenye [4234 2182 2814]: "Development of Ordos Plateau Accelerated, State Focusing on Construction of Energy Resource Base Area"]

[Text] During the Eighth 5-Year Plan, the Chinese Government plans to invest over 10 billion yuan renminbi focused on construction of the Ordos plateau in Inner Mongolia.

China's biggest coal construction project at present, the Jungar coal-power- highway first phase project in eastern Ordos, will involve a total investment of 4.15 million yuan renminbi. Mine construction and overburden stripping are proceeding smoothly now and it is expected to produce coal and power and be opened to traffic in early 1993.

Preliminary construction at Dongsheng coal field, located in southern Ordos, has already completed an investment of more than 600 million yuan renminbi and is now entering an even larger-scale construction phase.

The long-term plan for Dalad power plant, located in northern Ordos, calls for construction of Asia's biggest thermal power plant. The State Planning Commission has already approved the design task documents for installation of four 300MW generators for the first phase.

Site selection is now in progress for Wanjiazhai hydropower station in southeast Ordos, which will involve an investment of 4 billion yuan renminbi. A contract has already been signed with Hong Kong business interests for a joint investment to utilize the superior quality kaolin associated with Jungar coal field for construction of a plant with a yearly production capacity of 360,000 sanitary porcelain fixtures. Work to establish a large project for an integrated coal and petrochemical enterprise, a comprehensive development project for Dongsheng coal field, is now intensely under way.

Ordos plateau, a part of the loess plateau, is located in the southwestern part of the Inner Mongolia Autonomous Region and covers an area of 87,000 square kilometers. There are rich coal resources buried beneath 80 percent of the loess in this area. It now has proven coal reserves of 105 billion tons. State plans call for yearly coal output of 30 million tons and an installed electric power generating capacity of 1,050MW in this area by 1995, and it has a population of only 1 million people.

Today, as construction of key state projects pushes forward, changes are now occurring regarding people's concepts. The view looking out over the high loess slopes is one of crisscrossing high-voltage power transmission lines and mine construction sites scattered everywhere. Construction to support key state construction and promote construction of a base area for local construction materials, petrochemical, high energy-consuming products, and non-staple food products and to convert resource advantages into economic advantages is now proceeding methodically.

Lubuge Hydropower Station Finished

40100058A Beijing CHINA DAILY (Economics and Business) in English 20 Jun 91 p 2

[Text] The Lubuge project, the nation's showcase hydropower development in South China, was completed over the weekend after nine years.

The last of the four 150,000-kilowatt generating units was put into operation last Friday, completing the 1.66 billion yuan ($313.2 million) project on the Huangni River between Yunnan and Guizhou provinces.

The station was partially funded by World Bank loans and was the first project in China to use them. It was also the first time that a Chinese firm had undertaken a hydropower project through international bidding.

The station is capable of producing 2.75 billion kilowatt hours of electricity a year at full capacity.

According to the State Energy Investment Corporation, Lubuge became the backbone of the Yunnan power network when its first generating units went into full commercial operation in December 1988.

Last year, power from the first three generating units helped to turn out 7.8 billion yuan ($1.47 billion) worth of industrial and agricultural products, which brought in about 2.6 billion yuan ($490 million) in profits and taxes for the State.

The government hailed the project as a treasure-house from which many of China's industries should learn valuable lessons in terms of the introduction of foreign funds, technologies and management.

The provinces of Yunnan and Guizhou are known to be rich in water resources but poor in capital.

"Along with the World Bank loans came advanced methods, including better design, open bidding, and a more efficient management system," said an energy expert.

Officials in charge of the project said they had gone through 15 designs and saved around 80 million yuan ($15.1 million) by contracting a water diversion project to a Japanese firm.

This practice was unprecedented among the nation's major capital construction projects. Chinese builders were, at that time, under no pressure to avoid poor quality and delays. This meant that additional investment was required frequently as the costs of construction went up.

"In fact, the Lubuge pattern has been applied to most of China's hydropower projects, especially those involving foreign capital," said an official from the State Energy Investment Corporation.

So far foreign capital has been introduced to 38 electric power projects involving nearly $8 billion.

Final Site Selection for Huge Xiaowan Project

916B0070A Kunming YUNNAN RIBAO in Chinese 16 Apr 91 p 1

[Article by YUNNAN RIBAO reporter Liu Zuwu [0491 4371 2976]: "Site Selected for Dam at Xiaowan Power Station, an Achievement in China's First High Dam Feasibility Research"]

[Text] After 8 days of on-site surveys, earnest discussion, and inspection by over 80 Chinese water conservancy and hydropower experts at Xiaowan hydropower station on the middle reaches of the Lancang Jiang, where China is now conducting feasibility research on its first high dam, a formal selection was made of the county seat of Fengqing County on 14 Apr 91.

This dam site selection conference, chaired by the Central Water Conservancy and Hydropower Planning and Design Academy in the Ministry of Energy Resources, was carried out on the basis of outstanding achievements in survey and design and scientific research concerning the Xiaowan dam site by the Kunming Survey and Design Academy over the past 13 years. The experts at the conference inspected and compared three dam segments at Xiaowan, Dawanzi, and Mingtong on the Lancang Jiang, which forms the boundary between Fengqing and Nanjian Counties. They felt that the terrain and geological conditions of the Xiaowan dam segment was better, that there would be smaller land inundation losses after the dam was built, and that comprehensive analysis of all the conditions indicated that it was superior to the two other dam segments. They decided to select the middle dam site in the Xiaowan dam segment which had been recommended by the Kunming Survey and Design Academy.

Xiaowan hydropower station is a key project for cascade development of the middle and lower reaches sections of the Lancang Jiang. The dam site selection report indicates that the power station dam will be about 290 meters high, with a reservoir capacity of 14.5 billion cubic meters and an installed generating capacity of 4,200MW.

Joint Investment in Lancang Jiang Development Outlined

916B0070B Kunming YUNNAN RIBAO in Chinese 1 May 91 p 1

[Article by YUNNAN RIBAO reporter Liu Zuwu [0491 4371 2976]: "Four Parties Including Guangdong, Yunnan, and Others Reach Agreement on Joint Investment To Develop Lancang Jiang's Hydropower Resources"]

[Text] All nationalities in Yunnan Province have dreamed of using development and utilization of Lancang Jiang hydropower resources to greatly accelerate the pace of construction. On 29 Apr 91, the Ministry of Energy Resources, State Energy Resource Investment Company, Guangdong Provincial People's Government,

and Yunnan Provincial People's Government reached an agreement in principle on joint investment to develop cascade hydropower stations in the middle and lower reaches of the Lancang Jiang. Vice minister Lu Youmei [7120 0147 2812] of the Ministry of Energy Resources said: "A gratifying step has been taken in joint investment to develop the Lancang Jiang to build an electric power corridor in south China and achieve the transmission of power from west to east China, and this is extremely important for electric power construction in China."

From 21 to 29 Apr 91, minister Lu Youmei of the Ministry of Energy Resources, State Energy Resource Investment Company general manager Yao Zhenyan [1202 2182 3508], Guangdong Province vice governor Kuang Ji [0562 0679], and Yunnan Province vice governor Li Shuji [2621 2885 1015], and officials from relevant departments made a joint inspection of the middle and lower reaches segment of the Lancang Jiang and decided to jointly invest in three large power stations on the Lancang Jiang at Dazhaoshan, Xiaowan, and Nuozhadu with a total installed generating capacity of 10,000MW. The main aspects of the agreement are: 1) Xiaowan power station, with an installed generating capacity of 4,200MW, will be built through a joint investment by three parties, Guangdong, Yunnan, and the State Energy Resource Investment Company, with the investment proportions being 60 percent for Guangdong, 30 percent for the State Energy Resource Investment Company, and 10 percent for Yunnan. The investors will have long-term property rights and distribute the power according to their proportional investment and construction will begin during the Ninth 5-Year Plan. The power transmission project to transmit power to Guangdong will be built through a joint investment by Guangdong Province and the State Energy Resource Investment Company, with Guangdong providing most of the investment. After the first generator at the power station goes into operation, Guangdong will deduct the plant gate cost electricity price for a specific proportion of the power supplied to the grid and give it to Yunnan as preferential support funds. For the cost of the preliminary design now being conducted at the power station, the Ministry of Energy Resources is providing 50 percent, Guangdong is providing 35 percent, and Yunnan is providing 15 percent. 2) Dazhaoshan power station, which will have an installed generating capacity of 1,260MW, is being built through a joint investment by Yunnan Province and the State Energy Resource Investment Company. Yunnan is providing 40 percent of the investment and the State Energy Resource Company is providing 60 percent. Each of the two parties will have ownership rights according to the proportion invested and they will share the electricity, the profits, and responsibility for the bonds. Inspection of the preliminary design must be completed in 1992 and they will try to start construction in 1993. At present, they must reinforce highway construction outside of the area. With agreement from the Ministry of Energy Resources, the proprietor units at Dazhaoshan power station will give responsibility to the Yunnan Provincial Electric Power Bureau, while the construction unit after the project is established will be the Manwan Power Station Project Management Bureau. 3) The four parties are unanimous in their view that construction conditions are rather good at Nuozhadu hydropower station and that the economic benefits are huge, so they are willing to use the arrangement at Xiaowan for further joint investment development and hope to begin construction of this power station during the later stages of construction at Xiaowan. The feasibility research report must be submitted in 1995 and the preliminary design must be completed by the year 2000. As for the cost of preparatory work, the Ministry of Energy Resources will provide 50 percent, Guangdong will provide 35 percent, and Yunnan will provide 15 percent. 4) A decision was made to establish a "preparatory work coordination group". This coordination group will be led by the Ministry of Energy Resources and the three remaining parties along with the Central Water Conservancy and Hydropower Planning and Design Academy and the China Southern Electric Power Joint Venture Company will participate to reinforce inspection of survey and design work and coordinate major questions in work.

Leaders in the Ministry of Energy Resources, State Energy Resource Investment Company, and Guangdong Provincial Government are extremely satisfied with the agreement they have reached with Yunnan. State Energy Resource Investment Company general manager Yao Zhenyan told reporters, "using a publicly-owned stock system for joint investment to develop the Lancang Jiang conforms to economic laws and will integrate Yunnan's hydropower resource advantages with Guangdong's huge market for electric power, which will greatly promote economic development in both Yunnan and Guangdong Provinces."

Work Accelerated on Main Portion of Giant Manwan Project

916B0070C Kunming YUNNAN RIBAO in Chinese 17 May 91 p 1

[Article by YUNNAN RIBAO reporter Wang Jiadong [3769 0857 2767]: "Main Project at Manwan Power Station Enters Peak Construction Period"]

[Text] Pu Chaozhu [2528 2600 2691] states after on-site inspection that the Yunnan Provincial CPC Committee and Provincial Government are satisfied with the overall construction. If the people of Manwan continue to foster the working style of arduous struggle and victory over difficulties, the spirit of exploration and reform to move ahead, and the style of uniting in cooperation and working hard together, they will certainly be able to place Manwan power station into operation and generate electricity by the end of 1992. We must do propaganda and advocate the spirit of Manwan people among the cadres and masses throughout Yunnan to promote work in all areas.

At a key time during the peak of concrete construction for the main project at Manwan power station, Yunnan Provincial CPC Committee secretary Pu Chaozhu inspected work at Manwan on 14 May 91 and called on all related areas to continue fostering the revolutionary spirit of the people of Manwan, unite in common struggle, overcome difficulties, and try in every possible way to place the project into operation and generate power by the end of 1992.

Manwan power station is one of the large 1,000MW hydropower stations now under construction in China as well as the power station with the lowest per unit kW construction costs. Everyone in Yunnan Province is extremely concerned with construction of Manwan power station. Comrade Pu Chaozhu has visited Manwan several times to inspect the work. This time, after doing 23 days of survey research on rural areas and plants in southwest Yunnan, he also endured the hardships of a long journey to Manwan. When he arrived at Manwan, Pu Chaozhu drove to the sites where the dam and buildings were being poured and the stone material and so on to understand the situation. Next, he held discussions with responsible comrades in all areas. At the meeting, Manwan Power Station Management Bureau manager and senior engineer He Gong [6320 1872] gave the first situation report. He said that construction of Manwan power station has now entered the period of main project construction. The pouring tasks for the large dam, plant buildings, and generator pits amount to 2.10 million cubic meters, of which 600,000 cubic meters had been completed through the first quarter of 1991. If we wish to place the first generator into operation and generate electricity by the end of 1992, we must complete the concrete grouting plans for the 750,000 cubic meter dam. Although there are many difficulties, the internal and external conditions for completing the task are basically in place and monthly pouring has held stable at 50,000 to 60,000 cubic meters for several months in succession. Stripping of the materials yard has entered the normal stage. Major achievements have been made in controlling landslips on the left bank and a basically stable gratifying scene has been opened up that has moved construction out of its difficult straits. The capital is already in place. The several units responsible for construction are united in cooperation and the overall situation is good. Of course, several problems exist in deployment of forces, allocation of raw materials, and other areas. Pu Chaozhu asked everyone, what difficulties and problems must be overcome in our effort to generate power and begin operation in 1992? Director Cao Baohua [2580 1405 5478] of the Manwan Branch Bureau of the 14th Hydropower Bureau said that after the flow is diverted, we will return to a secondary status and we will certainly play our role as a costar with the Gezhouba Construction Bureau well. At present, our welding and riveting cannot keep pace, so we are transferring reinforcements from Guangdong. CPC Committee secretary Yang Fengwu [2799 7685 2745] of the Manwan Branch Bureau of the Gezhouba Construction Bureau said "several parties are responsible for construction of Manwan and as the project has progressed we have already moved our bureau into the leading status in construction. We will continue to foster our advantages of a cooperative battle of many types of troops and many procedures, build the project well, and strive to place it into operation and generate power by the end of 1992. The problem is inadequate cement reserves and an incomplete variety of steel products". Pu Chaozhu said that the 14th Hydropower Bureau "played the dragon's head" in the flow diversion and that now the Gezhouba Construction Bureau was "playing the dragon's head". They must mutually match up and coordinate in the battle. The key power station projects in Guangdong which the 14th Hydropower Bureau was responsible for were done pretty well but they must be extremely concerned with doing good work on the Manwan power station project as well. Concerning the supplies of concrete, steel, and other materials, all of Yunnan Province will give preference to ensuring the needs of Manwan and will push to transfer a large group of materials and make more preparations before the rainy season arrives to ensure smooth progress in the project. Yunnan Provincial Economic Commission chairman Li Mingde [2621 2494 1795] accompanied Pu Chaozhu on his survey of southwest Yunnan and indicated on the spot that he would return to Kunming to coordinate and implement supplies of concrete, steel, and other materials. The Manwan Branch Bureau from the 8th Hydropower Bureau in Guizhou is responsible for excavation and supplies of sand and stone. However, they had never encountered rock as hard as they did at Manwan and there was major wear to their equipment, but deputy director Liu Shihua [0491 0013 5478] of the Manwan Branch Bureau stated categorically that "since we have gnawed into a hard bone and must also gnaw through the hard scalp, we certainly cannot hinder the project".

Will Manwan be able to go into operation and generate power at the end of 1992 as planned? Pu Chaozhu feels that this question must be considered in terms of its real economic significance and profound political significance. He said that Manwan is one of China's key projects as well as Yunnan's only biggest key project. It is the "pulse" of Yunnan's future economic construction. The State Council, Ministry of Energy Resources, Yunnan Provincial CPC Committee, and Yunnan Provincial Government have been extremely concerned with this project and are satisfied with the overall progress in the project. Now that it is entering the peak construction phase and the internal and external conditions are both very good, we must try in every possible way to place it into operation and generate power by the end of 1992. The reasons are: 1) Consideration of demand and benefits. A power shortage has already become a major factor restricting development of Yunnan's economy. For Yunnan as a whole, 1 kWh of electricity creates 2 yuan in value of output and benefits of 0.7 yuan, so 1,000MW Manwan going into operation and generating electricity 1 year or even 1 day earlier will

promote smooth development of the entire province's economy. 2) Consideration of the political effects. Manwan power station is a joint investment project for provinces and ministries throughout China. It is the first large power station to implement trial reform of contractual responsibility through bidding. The achievements in practice concern the reputation of the reform. 3) Consideration of fostering the Manwan spirit of the people of Manwan. After ground was broken to begin construction, the parties awarding contractual responsibility and the parties accepting contractual responsibility defeated one unthinkable difficulty after another and gained victory after victory. During the struggle against difficulties and obstacles, the Manwan spirit gradually took shape and Manwan become an advanced model for construction of spiritual civilization throughout Yunnan. To summarize the Manwan spirit, it is a working style of arduous struggle and boldly defeating all difficulties, a spirit of advancing through bold exploration and reform, and a style of cooperation and unity and common struggle. The news media, especially YUNNAN RIBAO, have done a great deal of propaganda promoting Yunnan Province's spiritual civilization construction. We also must do far-reaching propaganda and advocate the Manwan spirit among the cadres and masses through Yunnan to promote work in all areas. Thus, whether or not Manwan power station is able to go into operation according to plan concerns the reputation of the people of Manwan and the fostering and transmission of the Manwan spirit. 4) Consideration of the development of the Lancang Jiang basin. Manwan is the first power station among the eight cascade power stations planned for the Lancang Jiang. If we complete this "bearded project" and "haggling project", it will affect construction of several power stations in the future. If construction of the first power station achieves the results of conserving investments, short construction schedules, and good quality, it will be an excellent starting point and will inevitably promote and accelerate development of the Lancang Jiang basin.

Finally, Pu Chaozhu said movingly that if the people of Manwan just continue to foster the Manwan spirit, they will certainly be able to placed Manwan power station into operation and generate electricity on schedule. If no major objective factors occur, this goal can be attained. We warmly await the placing of Manwan into operation and power generation at an early date!

Nation's Coal Industry Now Largest in the World

916B0063A Xining QINGHAI RIBAO in Chinese 9 Mar 91 p 3

[Article: "China Has Built World's Largest-Scale Coal Industry"]

[Text] After 10 years of reform and 10 years of development, China has now built the world's largest-scale and highest-output coal industry. It has made major contributions to achievement of the first strategic objective in China's four modernizations drive and has laid a solid foundation for a takeoff of our national economy during the 1990's.

In 1980, on the basis of the state's strategic deployments, our coal industry formulated the strategic goal of doubling raw coal output by the end of this century to guarantee quadrupling of our GNP. The efforts of China's 7 million coal miners produced 1.03 billion tons of raw coal output in 1990, up 74 percent from 1980 and making China the world's biggest coal producer. Sustained growth in raw coal output has support the overall situation of reform throughout China and provided fundamental guarantees of the coal required for national economic and social development.

Over the past 10 years, the pace of mine construction was accelerated and there were substantial increases in production capacity. China completed and placed into operation 220 mineshafts nationwide under direct jurisdiction and providing direct supplies and added 175.63 million tons in new production capacity. The construction schedule for new mines was reduced to 70.46 months. While reinforcing construction at Huainan and Huaibei, Yanzhou, Kailuan, Datong, Gujiao, and other mining regions, construction of five large strip mines also got fully underway. We have begun construction of the new Huichun, Jining, Yongchen, Jincheng, and Luoan mining regions, and we have completed and placed into operation several large mines with high degrees of mechanization and high efficiency. Over the past decade, coal field geology departments have added 166.3 billion tons in newly proven reserves and turned over 57.4 billion tons of industrial reserves.

Reform and opening up have opened new vistas for coal industry development. Implementing a variety of ownership arrangements to develop mines has promoted major development of township and town coal mines. Implementation of a series of matching reforms centered on the contractual responsibility system in unified distribution coal mines has begun changing the situation of enterprises "eating from the big common pot" of the state and caused enterprises to shift from single products and single administration to diversified administration. We have also made major efforts to open up international markets and fought for higher economic benefits. Coal exports in 1990 were 2.8 times greater than in 1980 and they have become one of China's 10 largest export foreign exchange earning industries.

The China Unified Distribution Coal Mine Corporation is now holding a work conference in Beijing to study and decide on basic ideas for developing China's coal industry over the next 10 years. They have proposed the need to rely on S&T progress and intensive reform and opening up to achieve the magnificent goal of 1.4 billion tons in raw coal output by the end of this century.

Japan to Provide $58 Million for Tarim Survey

40100064 Beijing CHINA DAILY (Economics and Business) in English 6 Jul 91 p 2

[Article by staff reporter Yuan Zhou]

[Text] The Japan National Oil Corporation yesterday agreed to provide 8 billion yen ($58 million) to fund a geological survey in the oil-rich Tarim Basin—a major foreign stake in the future of the Chinese oil industry.

According to an agreement signed in Beijing, the study, to last four and a half years, will cover 30,000 square kilometers in the southwest part of the Tarim Basin of the northwestern Xinjiang Uygur Autonomous Region.

As the data from the investigation will be processed, analyzed and evaluated in Japan, the Japanese will share in the results of the joint effort.

The top Chinese leadership has been emphasizing the "strategic importance" of the exploitation of oil and gas reserves in the Tarim Basin, linking it to the nation's economic and social development over the next decade.

Oil industrialists believe that the Tarim Basin is likely to become the country's next major oil hub to succeed the older fields in East and Northeast China.

In late June, the Bank of China, the country's leading foreign exchange banking arm, signed an agreement with the China National Petroleum Corporation (CNPC) to provide a loan of $1.2 billion to increase exploitation of the oil reserves in the Tarim Basin.

The first batch of crude oil from the Tarim Basin left for refining in Gansu Province at the beginning of this year.

Japanese sources say that a technical session between the Japanese firm and CNPC will be held to discuss details for the execution of the pact.

A joint team composed of a dozen Japanese specialists and 200 supporting Chinese personnel is expected to start a full-scale survey in March next year.

While promoting the oil prospecting activities in the area, the Japanese say, they hope the survey will help to consolidate cooperation in the exploitation of oil resources with China.

Vice Premier Zou Jiahua said at the signing ceremony of the basic agreement that the Chinese Government was throwing its full weight behind the project and wishing it success.

Zou said the agreement would have "very good effects" on future cooperation between Chinese and Japanese oil industrialists.

As two powerful and experienced economic organizations, the Japan National Oil Corporation and CNPC should intensify their cooperation in the future, he said.

Wang Tao, president of CNPC, called on foreign investors to join Chinese efforts to develop its oil resources in southern China under the principle of equality and mutual benefits.

Tarim Gets $1.2 Billion Loan for Exploration

40100061 Beijing CHINA DAILY in English 29 Jun 91 p 1

[Article by staff reporter Zhu Ling]

[Text] China's oil industry yesterday received a massive loan to step up the exploitation of the country's vast oil reserves.

The Bank of China, the country's leading foreign exchange banking institution, yesterday signed an agreement with the China National Petroleum and Natural Gas Corporation to provide a loan of $1.2 billion to the oil industry, Xinhua reported.

The landmark agreement, which is believed to have been masterminded by the State Council, is designed to step up the exploitation of oil reserves in the Tarim Basin of the Xinjiang Uygur Autonomous Region, an area thought to represent the future of the nation's petroleum industry.

Premier Li Peng, who attended the signing ceremony in Beijing, said that the exploitation of oil and gas reserves in the Tarim Basin is of great strategic significance to the nation's economic and social development over the next 10 years.

He noted that several major breakthroughs have been made in locating oil and gas reserves in the Tarim Basin in recent years.

The Premier urged more efforts to be made to quicken the exploration and development of the newly-found Tarim oilfields, which are expected to play a decisive role in maintaining the stability and sustained growth of the country's petroleum industry.

Li said that the soft loan reflects the close cooperation between the country's banks and industrial enterprises.

The Premier said that the country's foreign exchange reserves, currently standing at $32 billion, must be used to support the nation's technical progress, energy exploitation and economic and technical cooperation with the outside world.

Oil exploration in the Tarim Basin has great potential, but it is capital-intensive, said Li, adding that foreign investment and advanced technology are needed.

Sources said that China is looking for a bigger foreign stake in its exploration of the Tarim oilfields.

Wang Tao, general manager of the China National Petroleum and Natural Gas Corporation, toured Japan,

Canada, and the United States in April to drum up foreign investment and look for new ways to expand cooperation.

He said on his return that foreign capital would be introduced for geo-physical prospecting in the Tarim Basin.

Oil experts say that the Tarim Basin, whose estimated oil and gas reserves are kept confidential, is likely to become the country's next major oil hub to succeed the older oilfields in East and Northeast China, which will account for more than 80 percent of the country's oil output in the next 10 years.

At the beginning of this year, the first batch of crude oil from the Tarim Basin left for refineries in Gansu Province, marking a new chapter for the country's oil industry, which turned out 138 million tons of crude last year. China is striving to reach an output of 145 million tons in 1995.

Early this month, China discovered another rich oilfield in the northern part of the Tarim Basin.

Oil Industry Strategy: 'Stabilize the East, Develop the West'

916B0072B Urumqi XINJIANG RIBAO in Chinese 13 May 91 p 2

[Article by XINJIANG RIBAO reporters Jiang Yifeng [5592 0001 1496] and Yi Min [5337 3046]: "Turpan-Hami Basin Now Arising"]

[Text] The petroleum industry has adopted the strategic principle of "stabilizing the east, developing the west" to ensure stable and increased output in old oil fields of east China and concentrate forces appropriately to reinforce exploration and development of new oil provinces in west China, mainly the Tarim and Turpan regions.

—From the "CPC Central Committee Proposals Concerning Formulating of a 10- Year Plan for National Economic and Social Development and the Eighth 5-Year Plan"

"Turpan" has been mentioned in a CPC Central Committee document!

We only know Turpan as the ancient village of grapes and did not know that Turpan is also an ancient village of petroleum. In the past, it was famous for its grapes but today it is known for its petroleum.

Aydingkol Hu within the borders of Turpan is the lowest area in Asia. In the Turpan-Hami Basin, which is below sea level, a major high-tech, high efficiency, and high-level petroleum exploration and development battle is unfolding. The status of the basin is now being uplifted and the basin is arising.

I. "The Jurassic System Is Not Friendly Enough"

The Turpan Basin is one of three large sedimentary basins in west China. It begins in the east at Hami (Kumul) and extends westward to Yuergou. It extends for about 600 kilometers from east to west and is 50 to 130 kilometers wide from north to south, covering an area of 48,000 square kilometers. The train on the Lan-Xin [Lanzhou-Xinjiang] railroad cuts across the basin and small oases flash by as it passes. The grassless and parched gravel of the desert is endless and gives one a sleepy feeling.

Petroleum exploration workers have been sentimental about this basin for decades.

From 1954 to 1957, the Xinjiang Petroleum Management Bureau left repeated tracks in this basin. Surface geology surveys and gravitational and magnetic measurements gave them a basic understanding of the region's geological outline, basement structure, formational characteristics, and oil generation and reservoiring conditions.

The Yumen Petroleum Management Bureau followed closely in their dust. At that time, Yumen oil field stood like the sun in the sky, accounting for one-half of total crude oil output in China. The people of Yumen were full of lofty ambition. The popular song "Whip a Fast Horse To Capture Turpan" was an exact expression of the lofty sentiments in the hearts of the people of Yumen at that time.

They worked for 6 years straight. It was hard for outsiders to comprehend the large amount of blood and sweat consumed in surface geology, gravitational and magnetic, electrical method, seismic, well drilling, comprehensive research, and other work. Some figures can illustrate this: they drilled 138 wells for a drilling footage of more than 130,000 meters, discovered two small oil deposits at Singim and Qiktim that did not have significant industrial exploitation value, and proved less than 2 million tons of geological petroleum reserves. The basin's answer to the enormous enthusiasm of those exploring for oil was too miserly and could even be called almost callous!

In 1964, China's petroleum industry met for battle at Daqing and the exploration staff in Turpan-Hami Basin "said goodbye to the desert and headed east". "The Jurassic system (the main exploration target strata at the time) was not friendly enough." The people of Yumen, anguished, burdened, unwilling, and reluctant, tossed aside this statement which was food for thought.

II. The First Report of Spring Flowers

Could the Jurassic truly fail to become a friend?

Exploration came to a standstill from 1965 to 1973. Xinjiang Petroleum Management Bureau silently but with foresight worked to put in order the basic data accumulated over the years in Turpan-Hami Basin. Many exploration workers who had worked in the basin

were infatuated with discussing the past. They offered this defense to absolve the fickle unkindness of the Jurassic system: our past failure to find large oil deposits can be blamed on our backward technology and understanding. Small drill rigs can only drill shallow wells and our logging tools were backward. Added to the immaturity of continental facies oil formation theory, our diagnosis of oil and gas indications and our interpretation of data were inaccurate....

Some people were even richer in ideas: Tarim, Junggar, and Turpan-Hami basins in Xinjiang should have been a single unified basin in the distant geological past and were only divided into three parts by subsequent uplifting of the Tian Shan mountain range. Large oil deposits have already been discovered in Junggar which had been cut off by the mountains and there was hope of finding large oil deposits in Tarim as well. Would Turpan-Hami have been left out in the cold by the Creator?

The ideas which accumulated over a period of time turned into new enthusiasm. At the end of 1983, State Council member Kang Shi'en [1660 0013 1869] chaired the Ministry of Petroleum Industr's Western China Exploration Conference and issued orders to resume development and exploration of the Turpan-Hami Basin for renewed understanding and assessment of the basin. Subsequently, first the Seismic Team of the Petroleum Geophysical Exploration Bureau and then the Yumen Petroleum Management Bureau and the Beijing Petroleum Exploration and Development Research Academy joined together in undertaking surface geology surveys and comprehensive research in the basin.

In September 1987, the No 6052 Drilling Team in Yumen Petroleum Management Bureau drilled the first scientific exploratory well decided upon in discussions chaired by the Ministry of Petroleum Industry, Tai parameter well 1, on the Shanshan (Piqan) structure in Turpan depression. At almost the same time, the curtain opened on a large-scale comprehensive prospecting battle in the basin.

Drilling the Tai parameter well 1 was very difficult and took more than 1 year. On 5 Jan 89, a page of major breakthrough significance was opened in the history of oil exploration in the basin: an industrial oil flow erupted from Jurassic strata in the Tai parameter well 1. Success was finally attained after several decades of prospecting and the dreams of millions of people finally became a reality. "Old Petroleum" stimulated a torrent of tears over the grand occasion as children and young people flung their hard hats into the sky and let go with shouts.

With deep feeling, people called the Tai parameter well 1 "the first flower of spring."

III. Three Ideas Intersect

After the gusher at Tai parameter well 1, prospecting work in Turpan-Hami Basin became an irresistible force and news of victory kept pouring in. Industrial oil and gas flows or excellent oil and gas indications were obtained at one new exploratory well after another. Achievements in finding oil expanded from a point like a whirlwind. Oil deposits were found at Shanshan, Qiuling, Yila Hu, and Wenjisang. The secret veil shrouding the structures in the basin was gradually lifted. The broad prospects for discovering oil which people longed for were clearly visible. If the Tai parameter well 1 could be called the first flower of spring, Turpan-Hami Basin over the next 2 years was a bright spring scene.

This bright spring scene rolled into a series of blueprints with bright prospects.

A. The state's ideas for developing the petroleum industry

The petroleum industry has consistently pursued development of the national economy like a steadily moving asteroid. The pace cannot be called fast, but competition between supply and demand was always present. During the Eighth 5-Year Plan and the next 10 years, given the precipitous increase in difficulty in petroleum development in east China and the closely following precipitous declines in production, new oil regions in west China will historically become strategic replacement regions for the petroleum industry. Turpan-Hami Basin has rich accumulations of oil and gas and concentrated battlefields, and it lies near lines of communication, so it is a realistic region which has the proper conditions to increase reserves and output during the Eighth 5-Year Plan.

B. Xinjiang's ideas for using a petroleum development opportunity

Petroleum can make our country and our province prosperous. If Xinjiang desires prosperity, then petroleum must be developed. If Xinjiang desires much greater prosperity, then petroleum must be developed in a major way. The strategic shift of our national petroleum industry to west China provides Xinjiang with an excellent opportunity seen only once in a thousand years. There are great hopes for letting petroleum development lead the way to promote development of related industries and thereby invigorate Xinjiang's economy and bring prosperity to the people of all nationalities.

C. Yumen Petroleum Management Bureau's ideas for "starting again at the eastern mountains, turning it into spring again"

Yumen oil field has a magnificent history. The "Yumen style" is well-known. However, as the years have passed Yumen oil field has grown old and it accounts for less than 1 percent of total output in China's petroleum industry. An opportunity to "start again in the eastern mountains" has now arrived. As the primary unit in the battle, if it can seize a large oil deposit in Turpan-Hami Basin with output 10 times that of Yumen now, that would be quite a stimulating situation!

The ideas of the state, local areas, and the leading unit are flowing together like three rivers of hope and joining

together at one point—accelerating exploration and development of Turpan-Hami Basin. This is a confluence of enthusiasm as well as a confluence of forces.

IV. Unfurling a Bright Spring

After the China Petroleum and Natural Gas Corporation readjusted its exploration and development deployments and reinforced the leadership forces in the battle command at Turpan-Hami oil field, the scale of the battle at Turpan-Hami has gradually expanded and staffs have moved forward energetically.

Around the time of the Spring Festival [lunar new year] in 1991, there were fewer than 5,000 people in the area of battle. This number had grown to 12,000 by mid-April and troops of all sorts continue to arrive. Besides the main staff at Yumen, the North China Petroleum Management Bureau, Changqing Petroleum Exploration Bureau, and Petroleum Geophysical Exploration Bureau have all assigned crack troops to participate in the battle. Over 20 scientific research academies and institutes all over China have dispatched technical service and consulting staffs. The crack troops in the battle area are flowing together like powerful clouds and are at the vanguard in China both in equipment and technology.

At the battle headquarters at Dabenying, east of the Shanshan County county seat, there is an atmosphere of bustling activity. Trucks of all brands and models arrive and leave as they go to forward positions in the prospecting region or return from there, raising the dust as they move. Every day strange faces arrive to make reports or inspections or seeking cooperation. Covered in dust and unable to wash, they rush about on their trips. Office telephones ring incessantly, transmitting in in the sounds of requests for instructions, reports, requests for reinforcements, and reports of victory as they send out the sounds of dispatches, commands, consultations, and congratulations for victory. The number of personnel is swelling and they have run out of houses. Construction of temporary housing is now pressing forward day and night at Yuandong, a construction site laden with red bricks, and the noise of locomotives and people is heard without letup.

The commanders leading the battle staffs are facing thousands of tasks. Drilling, building output, producing oil, project design, examination and approval, construction, importing automated equipment, training staffs, and organizing production all seem to go on simultaneously and a series of problems involving water, electricity, transport, communications, and highways all seem to be solved simultaneously. Moreover, standards cannot be lowered and procedures cannot be exceeded, but the pace must still be accelerated! China Petroleum and Natural Gas Corporation deputy senior geologist Tan Wenbin [6223 2429 1755], who is over 60 years old and serves as headquarters commander as well as working committee secretary, arrived in Turpan City from Beijing travel-worn and weary to meet with experts from foreign companies to discuss a design program for the oil field. Headquarters working committee routine business deputy secretary Wang Peng [3769 7720] often works until 1:00 or 2:00 o'clock at night and returns to his dormitory to rest in the dead of night. His driver said he sometimes eats only half a mantou [steamed rice flour bun] for a meal. Routine business deputy commander Zhao Xishou [6392 3556 1108] worked at such a feverish pace 24 hours day and night that he even experienced difficulty in sleeping and was forced to follow his doctor's orders and take some time off from work.

The exploratory drilling region is another scene of bustling activity: drilling rigs stand like trees and the drill engines roar day and night; trucks shuttle back and forth, raising clouds of dust; exploratory drilling teams pursue each other and set new production records every day and every month. The Yumen drilling team had just set a record by taking just 11 hours and 15 minutes to move, set up, and begin drilling, but it was beaten 3 days later by the North China Drilling Team, which did it in 9 hours and 40 minutes. The biggest concern of the exploratory drilling employees is the raising and lowering of the red team banners among the forest of banners by the battle command because their honor or disgrace are clear in a glance in the rapid raising and lowering of the banners placed in the public eye!

Complete 5 years of tasks in 3 years and seize a major oil deposit as soon as possible! This is the iron and steel oath taken by the battle staffs at Turpan-Hami. Their burning enthusiasm and surging morale is now spreading through the basin, dispersing a bright spring scene.

Three Big Natural Gas Facilities To Be Built in Eastern Qaidam

916B0072A Xining QINGHAI RIBAO in Chinese 28 Mar 91 p 1

[Article: "Three Natural Gas Projects To Be Built in Eastern Qaidam, Stabilize Output from Western Qaidam Oil Field, Speed Up Development of Eastern Qaidam Gas Field, China Petroleum and Natural Gas Corporation General Manager Wang Tao [3769 3447] and Qinghai Provincial CPC Secretary Yin Kesheng [1438 0344 0581] Visit Qaidam Oil Field for On-Site Meeting and Discussion of Important Matters in Oil and Gas Development"]

[Text] During the Eighth 5-Year Plan, three natural gas development and utilization projects will be conducted in Qaidam Basin in eastern Qinghai Province: completion of a 1 billion cubic meter gas field, deployment of a gas transmission pipeline to Golmud, and construction of a methanol plant.

These three inspiring gas field development projects following the three petroleum projects at Qaidam were decided upon during consultations in a 5-day on-site meeting at Qaidam oil field from 15 to 20 Mar 91 between CPC Central committee member and China

Petroleum and Natural Gas Corporation general manager Wang Tao and CPC Central Committee member and Qinghai Provincial CPC secretary Yin Kesheng.

On the afternoon of 27 Mar 91, the Qinghai Provincial CPC Committee convened a meeting of cadres at the deputy provincial level and above to listen to a report by comrade Wang Tao concerning the petroleum and natural gas development situation at Qaidam. While discussing adoption of the strategic principle of "stabilizing eastern Qaidam, developing western Qaidam" in the petroleum industry, comrade Wang Tao pointed out that: "the center of the petroleum industry must shift gradually toward the vast northwest area of China with its abundant petroleum resources, Qinghai will be one of the key battlefields, and there are broad prospects for development of oil and gas in Qaidam Basin. The reserves in the gas-bearing strata of the eastern part of the basin are concentrated and buried at shallow depths, so development of natural gas in eastern Qaidam should become the order of the day and we must accelerate the pace of development. During the Eighth 5-Year Plan, we plan to build three gas projects here."

During the on-site meeting, general manager Wang Tao warmly congratulated petroleum workers at Qaidam as being a staff capable of fighting hard battles. Their spirit of taking root on the plateau, arduous struggle, indomitable readiness to risk their lives, and selfless tribute are especially admirable.

Wang Tao made a long and arduous journey without concern for several days of difficult travel and the shortage of oxygen on the plateau, accompanied by comrade Yin Kesheng, to visit over 10 drilling teams, oil extraction teams, plant sites, workshops, oil transmission pumping stations, employee and family dormitories, and Dunhuang base area to talk personally with workers and their families, asking if they were cold or warm, making inspections and guiding work, and visiting with the drilling team workers at the world's highest oil well, the Shi-20 well.

Qinghai Provincial CPC Committee Standing Committee member and provincial vice governor Cai Zhulin [5591 4554 2651] said at the meeting that Qaidam Basin has rich oil and gas resource reserves with much hope for their development, which actually made him feel many times more encouraged. He considers development of Qaidam's oil and gas resources to be an achievement of the state. a major undertaking which will provide benefits for 1,000 years, and an important matter which will be developed by the people of all nationalities in Qinghai. He called on behalf of the Qinghai Provincial CPC Committee and Provincial Government for coordinated efforts to establish the three gas field development projects, begin construction, place them into operation, and achieve benefits as quickly as possible.

Vast Gas Deposit Discovered in North

40100063 Beijing CHINA DAILY in English 24 Jun 91 p 1

[Text] One of the largest natural gas deposits in the world has been discovered in North China.

The 3,200-square-kilometer deposit is eight times the size of the country's existing major onshore gas field, according to a report in PEOPLE'S DAILY.

Chinese geologists and engineers say the deposit, located in the Jingbian-Hengshan region, the central part of the Shaanxi-Gansu-Ningxia Basin, is notable for its low exploration costs and excellent gas quality.

The size of the new gas field will create tremendous economic benefits for the border area of Shaanxi and Gansu provinces and the Ningxia and Inner Mongolia autonomous regions—one of the poorest areas on the mainland. It will also play an important role in China's economic development in this decade.

With exploration still continuing, the true size of the deposit is expected to extend from the Shaanxi border region into Ningxia and Inner Mongolia, said Shi Xingquan, director of the Changqing Petroleum Exploration Bureau, in charge of the project.

The Central government has decided to speed up development of the new field with preliminary targets set at an annual output of 3 billion cubic meters of natural gas per year. A feasibility study is already under way, and the project may be launched before the end of this year.

In the wake of a successful prospecting drive last year, large-scale exploration in the area this year has produced encouraging results.

Shi pointed out that every well drilled in the first five months of this year has struck gas with an average daily output of about 200,000 cubic meters. The highest production for a single well reached more than 1 million cubic meters.

As the second largest basin on the mainland, the Shaanxi-Gansu-Ningxia Basin occupies an area of 370,000 square kilometers and borders on five provinces and autonomous regions including Shaanxi, Gansu, Shanxi, Inner Mongolia and Ningxia.

With untapped reserves of coal, oil and natural gas, the basin was known for its people's poverty, mainly due to the harsh climate and shortage of water, leading to low agricultural output.

The Changqing oil field has been exploring the area [sic] since the late 1970s and turned out some 1.47 million tons of oil last year.

China has intensified its oil and gas exploration in a bid to put a halt to shrinking oil and gas deposits. Last year, the country's oil output was 138.3 million tons and gas output was 14.7 billion cubic meters.

The government has designated four areas for gas exploration. These, besides the Shaanxi-Gansu-Ningxia Basin, include the Tarim Jungar and Qaidam basins in Northwest China, where large- and medium-sized gas fields are expected to be found, the northern part of the South China Sea and East China Sea, and thirdly, the Bohai Bay and Songliao Basin.

Rich Oil Field Found in Xinjiang

40100054 Beijing CHINA DAILY in English 4 Jun 91 p 1

[Article by staff reporter Xu Yuanchao]

[Text] China has discovered a large new oilfield in the northern part of the Tarim Basin, in China's northwest Xinjiang Uygur Autonomous Region, the China National Petroleum Corporation (CNPC) announced in Beijing yesterday.

Two exploratory wells, drilled in the Jilake area last week, were gushing oil of "industrial value", and drilling of four other wells is now under way, said a CNPC official.

Li Ganshen, deputy chief geologist of the corporation, told a press conference that the Lunnan-57 well was tested to a production level of 445 cubic metres (equivalent to 2,923 barrels) of crude oil, plus 289,000 cubic metres of natural gas per day.

"The oil is of high quality and has a solidifying point of 11 degrees centrigrade below zero," Li said.

Another well, the Lunnan-58, was completed last Wednesday and was tested to a production level of 345 cubic metres (about 2,266 barrels) of oil and 552,000 cubic metres of gas daily.

The test well, about four kilometres from the Lunnan-57, was drilled to a depth of 4,300 metres when it hit oil in the stratum datable to the Triassic period (about 180 million years ago). The size of the oil-bearing strata was estimated at 60 square kilometres.

The two wells have not reached the designed depth of 5,500 metres but geologists predicted that they would also hit oil in the deeper stratum dating from the Carboniferous period (about 300 million years ago). This structure is estimated to cover an area of 130 square kilometres.

At the news conference, Li described the Jilake oilfield as "well preserved" and "an important find", following the earlier discovery by Chinese geologists of the Lunnan oilfield.

According to CNPC, the corporation has drilled 48 wells in the Tarim Basin and 28 have produced oil and gas.

Qinghai Field Could Have 1.2-Million-Ton Capacity this Year

916B0073C Guangzhou NANFANG RIBAO in Chinese 10 Jun 91 p 3

[Text] The Qinghai oil fields in the Qaidam Basin are accelerating development. This year it is hoped that a production capacity of 1.2 million metric tons of crude oil can be reached, and that in the Eighth 5-Year Plan it will become an important West China oil and gas production base. The Qaidam Basin is rich in oil and gas resources, with petroleum deposits of over 2 billion tons. In the Seventh 5-Year Plan national investments for oil and gas prospecting and development in Qinghai oil fields was 2.62 billion yuan, equal to the total investment of the previous 30 years. In the last 5 years, Qinghai oil fields have proved to possess large oil and gas reserves with a potential annual yield of 1 billion cubic meters of natural gas. There are 108 new wells that have reached or exceeded planned output capacity. Last year's crude oil output was sharply increased to more than 800,000 metric tons.

More Exploratory Wells in Jilake Producing Oil, Gas

916B0073B Beijing RENMIN RIBAO in Chinese 4 Jun 91 p 1

[Article by Huang Xianhua [7806 2009 5478]]

[Excerpt] [passage omitted] The Jilake section is located in northern Tarim and encompasses 40,000 square kilometers. It was opened up in the latter half of 1990 when the Tarim Petroleum Prospecting and Development Directorate began exploratory drilling at key points, and after great efforts two exploratory wells produced high volume oil and gas flows, and four other exploratory wells turned up oil layers or found good indicators for oil and gas.

The two exploratory wells that have high flows of oil and gas are the Lunnan-57 and Lunnan-58. These two exploratory wells produced oil and gas throughout May of this year. The former's daily output of crude oil was 445 cubic meters, and its output of natural gas was 289,000 cubic meters. The latter's daily output was 345 cubic meters of crude oil, and 552,000 cubic meters of natural gas. The geological data of the two wells proves that Jilake oil field is ready and waiting, its oil strata are consistent and contain light crude, and conditions for development are good.

Chishui, Guizhou Province, To Be Site of Major Exploration Effort

916B0073A Guiyang GUIZHOU RIBAO in Chinese 16 Apr 91 p 1

[Article by reporter Tang Wanming [0781 5502 2494]]

[Excerpt] The Chishui gas field and Guizhou Prospecting Directorate have announced that the China

Petroleum and Natural Gas Corporation has designated the Guizhou Chishui gas field as a key area in the Yunnan, Guizhou, Guangxi prospecting region's Eighth 5-Year Plan. This year's investment will be more than double that of last year, and the work force has already been increased by 50 percent.

Guizhou, well known for its voluminous oil and gas seepage from marine carbonate rock deposits, has been explored and studied for over a half-century, and according to evaluation and estimates of the oil and gas reserves for the whole province, by the end of the 1980s they were 29.11 million to 220.76 million metric tons of oil, and 132 to 449 billion cubic meters of gas. The China Petroleum and Natural Gas Corporation considers it to be the most important area for carbonate rock deposits. It has taken over as the logistical base for oil and gas prospecting, and Chishui oil field is the key location for oil and gas prospecting and development in the Yunnan, Guizhou, Guangxi region. The Corporation and the Yunnan, Guizhou, Guangxi Petroleum Prospecting Bureau's planned investment for oil and gas prospecting and development in Guizhou is over 26 million yuan, of which the Chishui gas field investment will be over 24 million yuan, more than double that of last year.

In the first half of last year, in order to step up the pace of exploration and development of the Chishui gas field, the Guizhou Petroleum and Development Directorate constantly dispatched units and facilities into Chishui, and set up a Chishui oil and gas prospecting project management department to handle the project. Geological conditions at Chishui are complex and progress is slow, which increases the hazards and difficulties of exploration. To increase the drilling rate and assure safety, the project management department is using advanced digital seismology, jet bit drilling, strike drilling, drill control, well-logging and monitoring technology. The drilling of the newly opened No 16 well in the Taihe [1132 0735] structure, and No 7 in the Wanglong [2489 7127] structure were begun in late August and early December of last year, respectively, and by the end of March those two wells had been drilled to depths of 2145.4 meters, and 1472 meters, reaching, respectively, 76.7 percent, and 50.8 percent of their planned depths. During the drilling there were many flows and gushers, all of which were promptly controlled, and the tests that were done in the process showed the Wang-7 well had good quality oil and gas. In order to speed up the work this year, bureau and directorate personnel worked on site many times, and by early April the number of workers at the gas field grew to more than 800. It is expected that test drilling of the two new wells will be completed in April and July. Concurrent with this, the two- and three-dimensional seismic profiling was underway. The national exploitation plan levied on the gas wells this year is 36 percent greater than last year, and through great effort in the first quarter a total of 4.37 million cubic meters of gas was supplied to the Chishui natural gas chemical fertilizer factory. [passage omitted]

Progress in FBR Research

916B0069B Beijing RENMIN RIBAO HAIWAI BAN in Chinese 22 May 91 p 4

[Article by reporter Hu Nianqiu [5170 1628 4428]: "China Makes Breakthroughs in Fast Breeder Reactor [FBR] Research, Several Research Projects Approach or Attain Advanced International Levels"]

[Text] China has reinforced FBR research and made breakthroughs in several important realms like FBR design, technology, fuel materials, safety, and so on.

FBR refers to fast neutron breeder reactors, nuclear reactors which use sodium as a moderator and are more advanced than conventional pressurized-water reactors. They can substantially increase the utilization rate of uranium resources and are inherently safe in that they are capable of automatically returning to a safe state in the event of any type of serious accident and pose no threat to the environment or populace, so they are an important foundation for construction and development of advanced nuclear power. Only a few nations in the world are capable of building and operating them at the present time.

China began studying FBR in the 1960's. Since 1987, FBR research has been included in the state's "863" high-tech research plan and has made many important achievements. China has now basically completed a conceptual design for FBR and decided upon the structural configuration and system parameters of the reactor itself and the fuel and operating systems, and decided upon an inherently safe design program. Substantial progress has been made in FBR structural materials design and research and in safety analysis. China has also developed a high-density core block with a theoretical density of 95 percent. We have made several key breakthroughs in sodium technology. China has also made new breakthroughs in monitoring and debugging trace hydrogen. Not long ago, China's "863" Experts Group made a comprehensive assessment of FBR research achievements during the Seventh 5-Year Plan and the results showed that among the 58 research projects concerning FBR completed by the relevant research academies and nuclear fuel plants in the nuclear industry and other academies and institutes and institutions of higher education, 28 were assessed at superior quality and 26 approached or attained advanced international levels.

The China Nuclear Industry Corporation recently pointed out that strengthening research on FBR has strategic significance for the development of FBR and China's nuclear power industry. China has now formed a powerful preliminary design staff for FBR research and design.

Qinshan Update

916B0069A Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 11 May 91 p 1

[Article by Zhang Ning [1728 2899] and Fu Rong [4395 2837]: "China Construction Science Research Academy Completes World's Second 1/10th Scale Prestressed Concrete Containment Vessel Destruction Experiment, Results Show that Qinshan Nuclear Power Plant's Containment Vessel Is Sufficiently Safe, Capable of Withstanding 3 Times the Accident Limits and Magnitude 7 Earthquakes"]

[Text] The containment vessel at the first nuclear power plant designed and built by China herself, Qinshan nuclear power plant, has a design safety coefficient of 2.8, but is the safety in the design theory actually reliable? The China Construction Science Research Academy's special prestressing chamber which completed a key state project to attack S&T problems during the Seventh 5-Year Plan, "Analysis of Load-Bearing Capabilities of Prestressed Concrete Containment Vessels", has provided a firm answer: Qinshan nuclear power plant has 3 times the load-bearing capacity of accident limits and can withstand magnitude 7 earthquakes.

A nuclear power plant's containment vessel is a sealed container that encloses the entire reactor plant building and its loop systems. It performs two functions: internally, withstanding internal accident pressures, limiting the release of radioactive material from the reactor system, and in particular, limiting its outward dispersal in the event of a serious loss-of-coolant accident. Externally, it protects the reactor plant building from destruction by outside collision. In 1979, an accident at the Three Mile Island nuclear power plant in the United States brought the safety properties of nuclear power plant containment vessels to the world's attention. The state project to attack key S&T problems during the Seventh 5-Year Plan, "Analysis of Load- Bearing Capabilities of Prestressed Concrete Containment Vessels", which was taken on by the China Construction Science Research Academy in 1987 is a large-scale and highly-difficult experiment. The model casing they chose is a 1/10th scale mockup of the Qinshan nuclear power plant containment vessel. The S&T personnel overcame many difficulties like materials selection, pressurization, measurement, being pressed for time, and so on and fully completed the experiment. This achievement from both the model experiment and theoretical analysis aspects confirmed that the containment vessel at Qinshan nuclear power plant, which China designed and built herself, has adequate safety properties and provided important demonstration material for operation and safety inspection of Qinshan nuclear power plant and provided a basis for China's future design of nuclear power containment vessels and compilation of the relevant regulations.

Searches of S&T information indicate that this was the second such experiment in the world (the first was conducted in England in 1989 by England, the United States, Japan, France, and other countries). Over 300 related experts from China and several 10 foreign experts from the United States, Canada, Finland, and other countries visited the experimental model and consistently assessed it as having attained advanced international levels.

Prospects for Domestic Development of Modular HTGR Nuclear Power Plant

916B0064A Beijing HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 12, No 2, Apr 91 pp 1-6, 18

[Article by Yang Yue [2799 6390] of the China Nuclear Power Research and Design Academy, Chengdu: "Development Prospects for Modular High-Temperature Gas-Cooled Reactor Power Plants in China"; MS received 15 May 90, revised 15 Jul 90]

[Text] Abstract: This article provides a brief description of the development situation and characteristics of modular high-temperature gas-cooled reactors (MHTGR), evaluates the necessity, technical capabilities, and economy of building this type of nuclear power plant in China based on the results of independent feasibility research for the Chongqing MHTGR power plant, analyzes problems and ways to solve them, and describes the importance and possibility of using a Chinese-foreign joint investment arrangement and progress that has already been made.

Key terms: modular high-temperature gas-cooled reactor, necessity, technical capability, Chinese-foreign joint investment.

I. Introduction

Five high-temperature gas-cooled reactors which use helium gas as a coolant and graphite as a moderator and which use coated particle fuel have now been completed in the world. The original intention in building them was their eventual commercialization. Due to the depressed nuclear power market in the West, successive order cancellations, and competition from pressurized water reactor [PWR] industry groups, the initial step has been difficult. In a situation of gradually strengthening anti-nuclear forces in the West and nuclear safety becoming a serious obstacle to the development of nuclear power, the United States and the Federal Republic of Germany began an immediate transition to modular high-temperature gas-cooled reactors (MHTGR) in 1984 and used their inherent safety and better economy as a second generation nuclear power source to begin competing with other reactor types. MHTGR started receiving governmental and public support and the development of MHTGR entered a new phase.

China's development of MHTGR is identical to trends in foreign countries, as we are now in a rising phase. The State Science and Technology Commission's high-tech plans call for construction of a 10MW experimental MHTGR. Moreover, Chongqing City and Dongfang Power Plant Equipment Set Company have jointly organized a "Chongqing High-Temperature Gas-Cooled Reactor Nuclear Power Company" Preparation Group that is now completing independent feasibility research and preparing to join in international cooperation to conduct feasibility research and is exploring the possibility of using Chinese-foreign joint investment to build a 300MW_e-grade MHTGR power plant.

Previous experience with high-temperature gas-cooled reactor construction and operation were used as a basis for making several improvements and simplifications in the design for MHTGR to give them better reliability and safety characteristics. There are no foreseeable insurmountable technical problems and businesses in foreign countries that are responsible for construction have made a bold guarantee. If power plant load factors fall to reach 80 percent, they will assume responsibility for compensating the economic losses. Of course, because MHTGR have not yet entered the commercial stage, economic risks like delayed construction schedules, over-budget expenditures, and so on cannot be eliminated at present.

II. Characteristics of MHTGR

There are two MHTGR designs in the world at present, the United States' MHTGR-350 and the Federal Republic of Germany's HTR-200. Their hot power is 350MW and 200MW, respectively, and their electric power is about 150MW and 80MW, respectively. Table 1 lists their main design parameters.

Table 1. Main Design Parameters of United States' MHTGR-350 and Federal Republic of Germany's HTR-200

Item		MHTGR-350	HTR-200
Reactor hot power, MW		350	200
Primary loop helium gas coolant	Pressure, MPa	6.39	6.00
	Core inlet temperature, °C	259	250
	Core outlet temperature, °C	687	700
	Flow rate, kg/s	157.2	85
Secondary loop steam	Pressure, MPa	17.3	19.0
	Temperature °C	541	530

Table 1. Main Design Parameters of United States' MHTGR-350 and Federal Republic of Germany's HTR-200 (Continued)

Item		MHTGR-350	HTR-200
	Output, kg/s	137.2	77
Core	Power density, MW/m^3	5.9	3.0
	Shape	Circular	Spherical bed
	Inner diameter, m	1.65	—
	Outer diameter, m	3.5	3.0
	Height, m	7.9	9.4
Fuel elements	Shape	Hexagonal cylinder	Spherical
	Dimensions, mm	790 X 360*	φ60
	Load, number	660	360,000

*Height X Span distance

The MHTGR is an advanced reactor. Its first characteristic is its inherent safety which meets the six requirements proposed by the United States' National Science and Technology Commission in 1983 for developing second- generation nuclear power plants: 1) Power plant safety must be unrelated to human operating errors; 2) The power plant must not leak radioactive materials that threaten man and the environment under any circumstances; 3) Power plant reliability can only be based on purely natural laws and cannot depend on complex engineering designs; 4) It the event of an accident, the power plant must be capable of automatic reactor shutdown; 5) In the event of a loss of coolant, there can be absolutely no melting of the reactor core; 6) The reactor must not be sensitive to chemical explosions or fire. United States reactor groups also feel that the nuclear safety characteristics of MHTGR are acceptable. Another advantage of this characteristic is that there are fewer restrictions on plant siting conditions. The radius of the restricted region for a $600MW_e$ MHTGR is 425 meters, so the plant can be placed near industrial load centers. This is especially importance for nuclear heat supplies.

A second characteristic of MHTGR is that the outlet temperature of the helium gas, the reactor coolant, can reach 700 to 950 °C. Thus, when using steam to generate power, secondary loop parameters can be matched to thermal power steam turbine generators. In the area of high-temperature heat supply, industrial steam with a variety of parameters can be generated that has a broad range of uses in chemical industry, petroleum, and other enterprises. As a development direction, it can provide many ways to use high-temperature gas directly for methane reformation and other purposes.

A third characteristic of MHTGR is a relatively high rate of nuclear fuel resource utilization. It has higher burnup of nuclear fuel than PWR and thorium can be used as a breeder fuel. General Atomics in the United States uses uranium with thorium as a breeder fuel, which can conserve 36 percent of the uranium fuel because it is consumed directly within the reactor as a breeder fuel.

III. The Necessity of Developing MHTGR Power Plants in China

An analysis of long-term nuclear power development and short-term user conditions within China indicates that China must develop MHTGR power plants. In the long-term view, because nuclear safety involves issues of international commonality, international changes in nuclear power will inevitably affect China's nuclear power development. MHTGR is a more feasible choice in the next generation of nuclear power competition due to its inherent safety. In the short term, as a supplement to China's primary type of nuclear power reactor, PWR, there are potential users for MHTGR power plants which exist under the following special conditions:

1. Certain industrial cities with dense populations. They either want to build nuclear power plants near load centers or build smaller-capacity nuclear power plants first for a variety of reasons. Examples include Chongqing, Wuhan, and other cities.

2. Heat and power cogeneration users such as Yanshan Petrochemical Plant, Shengli oil field, and so on. MHTGR power plants can generate steam with a variety of parameters and product grades and can be placed near users, a area where PWR cannot compete, and substituting nuclear power for high-priced oil is economically acceptable.

3. Frontier regions or those with very small power grid capacities like the Tibet region. They want to build very small capacity nuclear power plants and desire relatively simple operation so that operating errors or accidents would not have severe outcomes.

Under normal conditions, the larger the capacity of a nuclear power plant, the better the economy. However, the effects of capacity on economy for MHTGR power plants are smaller than those of PWR power plants, so MHTGR power plants are more competitive economically than PWR power plants when smaller capacity power plants are concerned. Economic analysis of MHTGR power plants published in the United States in

1989 indicates that in the United States situation, using Levelized Busbar Cost as an indicator, the price of electricity is \$0.05/kWh for $300MW_e$ and \$0.047 for $600MW_e$, which are superior to PWR power plants and coal-fired power plants. The price of electricity for $1,200MW_e$ is \$0.046/kWh, which is equivalent to the price of electricity from a PWR power plant. The results of economic analysis in China show that the economy of a $300MW_e$ MHTGR power plant is equivalent to the price of electricity for a PWR power plant of equal scale.

IV. Assessment of China's Ability To Build MHTGR Power Plants

China's electric power design academies are capable of taking on the design tasks for the conventional island portion of an MHTGR power plant. Conventional thermal power generators that China can produce as completes unit can be used for the steam turbine generator system and we have a rather substantial understanding. We can use Chinese-made equipment for 90 percent of the equipment, unlike PWR power plants which require nuclear bubble and steam turbines.

Licensed and approved designs from foreign countries can be used for the nuclear island portion of an MHTGR power plant, so we should depend mainly on foreign businesses for the basic design, and Chinese design units can assign a small number of key personnel to participate. Given China's high-tech plans and many years of development work, Chinese design units can play a substantial role in the basic design of the nuclear island and they can assume responsibility for the construction design for the nuclear island. Most of the auxiliary systems in the nuclear island equipment can be manufactured in China with considerable certainty, and they account for 27 percent of the total cost of the nuclear island equipment. Based on China's experience with PWR and production reactors, Chinese plants and businesses can assume responsibility for manufacturing tasks for the pressure vessels and support components and for the graphite blocks in the external reflection layer in the nuclear island equipment, so there is great potential for shifting to domestic production. We can consider importing the graphite blocks for the internal reflection layer and processing them in China. This portion accounts for 28 percent of the total cost of the nuclear island equipment. Thus, the proportion of domestic production for the nuclear island equipment can be 27 to 55 percent.

The control rods and fuel elements can be produced in China. We may have to import the first heat of fuel elements but we can begin using Chinese-made fuel elements with the first reloading.

China can assume responsibility for the civil engineering and installation work. Apart from this, we can consider participation by foreign businesses in project management and services. As for the question of the proportion of foreign businesses participating in this project, considering experiences in foreign countries and the advice of Mr. Garcia, who was general manager of a Spanish nuclear power company during the early stages, and Mr. Hamilton, an economic expert with the United States' General Atomics Company, we feel that, like Europe when it began importing PWR from the United States, we can play the dominant role ourselves and allow Chinese engineers to take on 85 percent of the work time and foreign engineers to take on 15 percent of the work time. A $300MW_e$ MHTGR power plant would take 50 foreign engineers working for 3 years at a cost of \$27 million.

The above analysis shows that China already has the capability of taking on most of the equipment manufacturing and project construction for MHTGR power plants and China's nuclear island equipment manufacturers will have to make greater efforts. The view that China at present is only capable of having a PWR power plant industry and technical foundation and lacks a foundation for MHTGR is wrong. Of course, in subsequent MHTGR power plant construction, China's technical capabilities will increase further.

V. An Economic Assessment of China Constructing MHTGR Power Plants

This economic analysis is based on the economic analysis in the independent feasibility research for the Chongqing MHTGR power plant.

A. An MHTGR power plant with a power generation goal of $300MW_e$

The nuclear power plant would use two MHTGR-350 reactor modules and one $300MW_e$ steam turbine. The data is based on cost estimates by the United States' Gas Cooled Reactor Association (GCRA) and cost estimates by China's Dongfang Power Plant Equipment Set Company and on information and stipulations in China regarding nuclear power plants and conventional power plants. The United States GCRA includes one-third of the electric power users in the United States. Some 75 percent of the cost estimates they make for equipment are based on price inquiries from at least four enterprises and their estimated costs are no lower than the reported costs of two enterprises.

The economic analysis uses 1987 base prices. The primary initial conditions are: power plant power $293MW_e$, yearly utilization rate 6,500 hours (based on Chongqing City's requirements, this actually could reach 7,000 hours), domestic production proportion for nuclear island equipment 27 percent (the actual figure may be higher), and total cost of participation by foreign engineers in project management and services \$27 million. The power plant would have a 30-year economic lifespan, 25-year depreciation schedule, 15-year loan repayment schedule, and 4-year construction schedule. The unexpected costs would be 25 percent for the nuclear island and 10 percent for the conventional island. To facilitate comparison with existing data on China's PWR power plants and coal-fired power plants, the exchange rate is assumed to be 3.72 yuan per U.S.

dollar and 2 yuan per Deutsche Mark. The yearly interest rate would be 3.6 percent for domestic currency and 8 percent for foreign currency and the floating rate would be 4 percent for both.

The results of the economic analysis are: excluding the cost of the initial fuel element loading, the basic investment in the power plant would be $160 million or 565 million yuan. The basic investment per unit of capacity would be 3,953 yuan/kW, which is 1.54 times the cost of an imported $700MW_e$ coal-fired power plant with desulfurization equipment. The construction cost per unit of capacity would be 5,054 yuan/kW, which is about 1.26 times that for a Chinese-made 2 X $600MW_e$ PWR power plant.

If we import the first heat of fuel elements, the marginal electricity selling price would be 0.18 to 0.25 yuan/kWh, the range of variation arising from differences in taxation policies. During the loan repayment period, 53 million yuan and $27 million would be needed each year, respectively, to pay off the principle and interest on domestic and foreign currency loans and registered capital income.

B. Using Chongqing City's Sichuan Fiber Mill As a Reference Plant Site For Economic Analysis of Heat and Power Cogeneration

We used the Federal Republic of Germany's HTR-200 design to prepare the following heat and power cogeneration program: The nuclear power plant would use four HTR-200 reactor modules and one $300MW_e$ steam turbine. Power output would be $220MW_e$ and yearly heat supply would be 7.6 X 10^9J, which is equivalent to supplying 400 tons of steam an hour. The steam parameters are: temperature 250 to 410 °C and pressure 1 to 3.9 MPa. The conditions of the economic analysis are basically identical to those for an MHTGR power plant designed to generate power. The only difference is the estimated cost of the equipment. The results of the economic analysis are: 1.46 billion yuan for the basic investments and 1.87 billion yuan for the completion cost.

If we import the first heat of fuel elements, when the selling price of steam is 4.8 yuan per 10^9J (1987 domestic stipulated price), the marginal electric power selling price would be 0.26 to 0.33 yuan/kWh. At a steam selling price of 11.2 yuan/10^9J, the marginal electric power selling price would be 0.20 to 0.27 yuan/kWh. For comparison, if the power plant did not supply heat but was only used to generate power, it could generate 345MW in electric power and the corresponding marginal electric power selling price would be 0.20 to 0.27 yuan/kWh. The range of variation in these electricity prices is due to different taxation policies. The comparisons show that although cogeneration could substantially increase the energy resource utilization rate (up to 70 percent), this does not necessarily mean that it would be economically rational. The deciding factor is the selling price of steam. Under conditions of using high-priced oil to produce high- priced steam, the selling price of steam could reach 12 yuan/10^9J (1985 local price) and at this time substituting nuclear power for oil to generate steam would be economical.

C. Economic analysis of Chinese-made fuel elements was done based on the following conditions: 40 million yuan for the plant construction investment, an annual interest rate of 8 percent for the loan, a 15-year loan repayment schedule, and fuel and materials prices based on 1987 stipulated prices in China. Data from foreign countries was used as a reference for workers in the production process, materials consumption, hydropower, and so on. It was also assumed that the fuel elements produced were supplied to only one $300MW_e$ scale MHTGR power plant.

The results of the analysis show that Chinese-made fuel elements would be 28 percent cheaper than imported ones and the fuel cost would be 0.024 yuan/kWh, which is equal to the parity price of coal.

Based on these results of the economic analysis, given China's present conditions and from an economics viewpoint, it would still be difficult for nuclear power plants to compete with coal-fired power plants and it would be difficult for MHTGR to compete with large PWR reactors. However, in regions with severe coal shortages, for construction of an approximately $300MW_e$ or even smaller capacity nuclear power plant or under conditions of substituting nuclear power for high-priced oil to produce product grade steam, the economy of MHTGR power plants would be acceptable and they would definitely be competitive.

The main economic problem with MHTGR power plants is the rather large proportion of foreign exchange involved in the investment and rather heavy foreign currency repayment tasks. The prospects for solving this problem are: first, by operating an experimental high-temperature gas-cooled modular reactor which could be built rather quickly, Chinese-made fuel elements could be inspected and approved. If they meet design standards, the first heat of fuel elements for an MHTGR power plant could be made in China, which could reduce foreign currency repayments by one-fourth. Second, striving to reach a 55 percent rate of domestic production for the nuclear island equipment (the economic analysis assumed 27 percent) could reduce foreign currency repayments by one-fifth. Third, try for preferential foreign currency loan conditions and seek a repayment arrangement that is acceptable to both the Chinese and foreign parties and that relies mainly on compensation trade.

The exchange rates and interest rates on domestic energy resource loans used for the economic analysis in this section no longer conform to China's current stipulations, so the analysis is useful only for relative comparisons. If the exchange rate is assumed to be 4.70 yuan per U.S. dollar, the basic investment per unit of capacity for

a 300MW_e MHTGR power plant would be 4,487 yuan/kW and the completion cost would be 5,885 yuan/kW.

VI. The Importance, Progress, and Prospects of Chinese-Foreign Joint Investment

Given our national conditions, the only way that China can build MHTGR power plants at the present time is, with a prerequisite of initiative from local governments and large companies, adopting a Chinese-foreign joint investment arrangement in which both the Chinese and foreign parties jointly invest in and manage the power plant. The reasons are:

1. The Chinese government has limited capital to develop nuclear power at the present time and will even find it difficult to pay for PWR construction. It cannot invest in MHTGR power plants. Moreover, a substantial amount of foreign exchange would be required for the basic investment in an MHTGR power plant and local areas would have problems raising it.

2. MHTGR power plants have not yet entered the commercial phase and economic risks cannot be eliminated. Adopting a Chinese-foreign joint investment arrangement in which both the Chinese and foreign parties jointly bear the economic risk could eliminate the doubts of the Chinese proprietors.

3. A Chinese-foreign joint venture could directly import advanced foreign equipment. The United States and Federal Republic of Germany have already spent several billion U.S. dollars to develop high-temperature gas-cooled reactors, so China would have no need to do so, nor could we take the route they have already followed. Directly applying and grasping advanced technology from foreign countries can form China's own high-temperature gas- cooled reactor industry rather quickly and allow us to enter the international MHTGR power plant market.

A program in principle that was acceptable to both the Chinese and foreign parties was proposed following long discussions with foreign businessmen: China would assume responsibility for the renminbi portion of the investment and the foreign party would assume responsibility for the foreign currency portion of the investment. Income from electricity sales would be used to repay the principle and interest on the investment. The Chinese and foreign parties would also seek a suitable foreign currency repayment arrangement, and the foreign party should provide loan finance conditions that are better than those for conventional nuclear power. This program in principle can be studied further in the Chinese-foreign joint feasibility research.

There is a possibility of Chinese and foreign joint investment. For foreign businesses, the most attractive aspect is that the Chinese-foreign joint venture could substantially reduce power plant construction costs. According to economic analysis, the basic investment per unit of capacity for a 300MW_e to 600MW_e MHTGR power plant would be $2,300 to $2,100 per kW in the United States and about $1,000 per kW in China. At present, with the depressed market for nuclear power in the West, foreign high-temperature gas-cooled reactor companies are anxious to open up markets and are revealing the advantages of MHTGR power plants for their existence and development. China has a definite nuclear industry foundation and technical strengths and a mature thermal power industry foundation, so we are a rather ideal cooperative partner. The United States' General Atomics Company and the Federal Republic of Germany's Interatom Company have agreed in principle to join together as the foreign parties in a joint venture with China. They will serve both as suppliers and as proprietors and will assume joint responsibility with the Chinese side for power plant construction and management. The "Chongqing High-Temperature Gas-Cooled Reactor Nuclear Power Company" Preparation Group composed of Chongqing City and the Dongfang Power Plant Equipment Set Company has expressed interest in a Chinese-foreign joint venture and assuming responsibility for the renminbi portion of the investment, and they have made a proposal concerning the foreign currency repayment arrangement in which the Dongfang Power Plant Equipment Set Company would use steam turbine generator system equipment as its investment. Both the Chinese and foreign parties have indicated that when the conditions are mature, they will organize the "Chinese-Foreign Joint Venture Chongqing High- Temperature Gas-Cooled Reactor Nuclear Power Company".

The International Atomic Energy Agency supports Chinese-foreign joint investment to build MHTGR power plants because this type of cooperation can popularize medium-sized and small nuclear power plants in developing nations. If China builds an MHTGR power plant and confirms its technical reliability and economic feasibility, it is entirely possible that China could cooperate with foreign countries to export this type of nuclear power plant.

Although a great deal of work has been done and progress has been made, the road we face in achieving our objective of Chinese-foreign joint investment is a very long one. On the basis of independent feasibility research completed in China, Chinese and foreign parties will do a joint inspection and perfect the economic analysis done by the Chinese side during 1990, after which joint feasibility research over 2 years may be necessary to solve some problems like capital conditions, cooperation models, and so on. China will also have to study licensing examination and acceptance questions. The foreign parties feel that passing the licensing examination and acceptance in China smoothly is equal in importance with the economic question. Construction of an experimental high-temperature gas-cooled modular reactor will help solve this problem.

There are no previous examples in the history of nuclear power where suppliers also serve as proprietors and this has vexed the bilateral discussions between China and the foreign parties for a long time. In feasibility research

for a commercial MHTGR power plant in the United States, a 1-year study was conducted and a concrete model was proposed in 1989 that has already been approved by all parties in the United States. Thus, the foreign businesses have already accepted this arrangement.

VII. Conclusion

An MHTGR power plant is inherently safe and is suitable for heat and power cogeneration, nuclear fuel conservation, and other competitive characteristics. No unforeseen or insurmountable technical problems exist. The development of MHTGR is now in a rising period internationally and China also has concrete development plans. Analysis of the two aspects of the long-term development of nuclear power in China and short-term potential users in China shows that China must develop this type of nuclear power plant to supplement PWR power plants.

China already has the ability to assume the responsibility for manufacturing most of the equipment and project construction to build China's first MHTGR power plant, but China's nuclear island equipment manufacturing plants must make greater efforts. Within the scope of medium-sized and small nuclear power plants or under conditions of substituting nuclear power for high-priced oil to generate product grade steam, an MHTGR power plant at the $300MW_e$ or smaller capacity scale is economically acceptable and definitely competitive. The main problem in the economic arena is the rather large amount of foreign currency involved in the investment and the heavy foreign currency repayment tasks, but this problem can be solved.

Given our national conditions, the only possible arrangement for building MHTGR power plants at the present time is Chinese-foreign joint investment with the Chinese and foreign parties jointly investing in and managing the power plant. Both the Chinese and foreign parties have expressed enthusiasm for this and definite progress has been made during more than 2 years of discussion and research. However, the present situation is still quite distant from achieving the objective of Chinese-foreign joint investment and a long period of arduous effort will be required.

Construction of an experimental high-temperature gas-cooled modular reactor in high-tech plans could effectively promote and support MHTGR power plant construction.

MHTGR power plants have a future and vitality in China. If we just work hard and gain the support of all areas, the prospects are bright. They will provide an essential supplement to China's nuclear power and prepare the conditions to transform nuclear power in China in the early part of the next century, which is very important for China's entry into the advanced nuclear power ranks of the world.

This article received direction from comrade Qian Jihui [6929 4480 1920] and support from Qu Zeyuan [4234 3419 3220], Wang Weihua [3769 0251 5478], Zhang Dachang [1728 1129 1281], Kang Shichu [1660 6108 2643], Ye Liangcheng [0673 5328 2052], Liu Zhuxuan [0491 4554 1357], and other comrades, and I would like to express my gratitude here.

Preparations for Experimental HTGR Project Now Underway

916B0064B Beijing HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 12, No 2, Apr 91 p 97 [inside back cover]

[Article by the High-Temperature Gas-Cooled Reactor Experts Group: "Major Advances in Work on Special High-Temperature Gas-Cooled Reactor Project"; MS supplied by Xu Yuanhui [1776 0337 6540]]

[Text] High-temperature gas-cooled reactors [HTGR] are one of China's high-tech plans. In the first step of our development strategy, during the Seventh 5-Year Plan, we focused mainly on research on key technologies to facilitate technical preparations to build an experimental HTGR during the Eighth 5-Year Plan. Between 30 Jan and 5 Mar 91, expert evaluations were made in Beijing of work done during the Seventh 5-Year Plan on eight topics and 43 sub-topics under the high-tech realm HTGR project. The experts fully confirmed the advances made in work and felt that breakthroughs had been made in several key technologies since 1987 and that some sub-topics had attained advanced international levels, which were very important for HTGR development.

1. Development, importation, and digestion of several dozen pieces of computer design software has enabled China to design HTGR. On this foundation, we completed a program design for an experimental 10MW HTGR and began preparing a preliminary design.

2. We developed manufacturing techniques for fuel elements on a laboratory scale. The cold-state performance indices of the fuel elements attained international levels and met design requirements. Satisfactory results were also obtained with the radiation properties of the coated particles.

3. We completed a middle-scale helium experiment loop that created the conditions for equipment performance testing and helium technology research. The helium purification technology and static sealing technology met design requirements and the technical indices of the small φ6 and φ12 diameter helium valves met requirements. The reactor core outlet helium gas mixing experiment console has been completed and is now being used for experiments.

4. We established a 1:1 spherical flow experiment console which can provide reliable data for designing the circulation of the fuel element spheres inside the fuel.

5. We have made developments comparable to technology in foreign countries for fuel element post-processing technology and techniques and established a cold-state experiment console with a daily processing capacity of 100 fuel elements that provides a very good way to fully utilize uranium resources.

Strategy of Developing New Energy Resources Outlined

916B0068 Beijing ZHONGGUO KEJI LUNTAN [FORUM ON SCIENCE AND TECHNOLOGY IN CHINA] in Chinese No 3, 18 May 91 pp 29-32

[Article by Zhu Shiwei [2612 0013 0251] and Cao Hengzhong [2580 1854 1813]: "Strategies and Countermeasures for Developing China's New Energy Resources"]

[Text] The present situation with world energy resources is extremely limited conventional energy resources and new energy resources that await development. In the area of conventional energy resources, high consumption of petroleum and natural gas means that reserves are already limited, while the situation with coal is slightly better, but traditional utilization technologies are creating severe environmental pollution. Hydraulic resources in the industrially developed nations have already been developed to the critical state. In this type of situation, all nations and particularly the industrially developed nations are beginning to shift their line of vision toward development and utilization of various types of new energy resources. Solar energy, wind power, and geothermal energy development and utilization were the first to be affected. Research on new technology for utilization of marine energy (including tidal energy, wave energy, salinity differential energy, and temperature differential energy) and biomass energy is now in progress. From the Second World War to today, the peaceful use of nuclear energy has developed in a surging way. As industry has developed and people's living standards have risen, demand for energy resources has grown continually, but the abrupt decrease in conventional energy resources now threatens mankind's development and existence, so the consciousness and concept of searching for new energy resources is growing among people and is becoming more urgent every day.

I. The Characteristics of New Energy Resources and an Assessment of the Current Situation

Like conventional energy resources, new energy resources are also converted from solar energy in different ways. Concretely speaking, new energy resources have the following characteristics: 1) Renewability. New energy resources do not exist in the natural world in the form of minerals but basically utilize solar energy directly, so in general they can be used in a cyclical fashion. 2) Resources are abundant. Man relied completely on the unending transmission of solar energy for centuries of his existence and development on Earth. Solar energy is inexhaustible and can never be used up. Even conventional minerals are the products of the effects of geochemical action on underground animals and plants by solar energy radiation. 3) Resources are relatively decentralized. Many new energy resources are not as concentrated as mineral and hydraulic reserves, which make large-scale development inconvenient. For a developing country like China, however, the scattered load of our vast rural area fits exactly with the decentralized distribution of new energy resource reserves so it is easy to find places where new energy resources can be used. 4) They are continuous and unstable. Solar energy, wind power, geothermal energy, and tides cannot be interrupted by annual, monthly, or seasonal changes. They are continuously generated. However, there are rather large variations in the amount of energy due to the effects of climate and celestial movement and they are unstable, which causes problems for development and utilization. 5) They are non-polluting. Most new energy resources do not cause environmental pollution like mineral energy resources, which helps improve the ecological environment. For nuclear energy utilization, using high-tech protection measures can ensure its safe operation. 6) Resource development and utilization are identical. There are no transportation problems with new energy resources since they are locally developed and locally utilized, which can reduce the investments and costs for development and production and even help with comprehensive utilization.

The structure of new energy resources is basically the same in China as in foreign countries. The development situation of China's new energy resources is as follows:

1. Solar energy: Solar energy is utilized in two ways, through the direct utilization of heat energy and for power generation. China now has over 1 million square meters of solar-powered hot water heaters and the pace of commercialization of solar-powered hot water heaters is accelerating. It will become the leading industry in solar energy utilization and its scope of utilization will expand from rural areas to cities. China has extreme problems with firewood in agro-pastoral areas of the northwest and Tibet. The long periods of solar energy irradiation in these regions are now being used to develop over 150,000 solar stoves which have alleviated the firewood shortage problems of these areas. China's solar cooking stoves are now world- famous and China has made substantial advances in research and application of solar-powered drying, solar-powered structures, solar batteries, and other areas and achieved excellent economic results.

2. Wind energy: The optimum form of wind energy utilization is power generation. Foreign countries have now developed wind-powered generators 9.7 m in diameter with an output power of 3.2MW. China has already produced miniature (below the kW grade), small (1 to 10 kW), medium-sized (10 to 100 kW), and large (100 kW and larger) wind-powered generator series. Wind- generated electricity is now making a transition from simple household use to electricity for production. In 1989, China had a total of 92,200 wind-powered generators with an installed generating capacity of 11.2MW. Xinjiang has invested 19 million yuan and is now building a wind-powered generating plant with an installed generating capacity of 10MW that will generate 50 GWh a year, the biggest in Asia. Power generated by wind power can be developed and utilized locally, which helps solve the problem of decentralized power supplies in pastoral

regions. Although the investment per unit kW may be high, their costs are still low. The second realm of wind power utilization is wind-powered water lifting, which is now in wide use along rivers and coastal regions. China now has 1,048 wind-powered water lifting machines that irrigate an area of 25,800 mu. Moreover, wind sails, refrigeration, and other forms of wind energy utilization have been developed in China and development work is now in progress.

3. Geothermal energy: In 1987, the world's total installed geothermal energy generating capacity exceeded 5,606MW, including 894MW in the Philippines and 228.7MW in Japan, second and sixth places in the world, respectively. China began using geothermal energy for power generation at Fengshun in Guangdong in 1970. Now, China's geothermal power plants have a total installed generating capacity of 22.3MW (including 3.3MW on Taiwan). China's biggest geothermal power plant is at Yangbajing (Yangbajan) in Tibet which has a total power generation capacity of 29.3MW, of which 19.3MW has already been developed. The reason for the slow development of geothermal power generation is the considerable technical difficulty and high investments, which are problems that deserve further exploration. China has a total capacity of 743MW for direct geothermal energy utilization, including 158MW in industry, 172MW in agriculture, and 413MW for household use, so there are rather good prospects for geothermal energy utilization.

4. Marine energy: The more mature technology for utilizing marine energy is tidal energy. France's (Langsi) tidal power station has an installed generating capacity of 240MW and generates 540 GWh of power annually. Canada is now building a tidal power station with an installed generating capacity of 1,428MW in the Bay of Fundy. China already has built eight small tidal power stations along the coast which are now in operation with a total installed generating capacity of 11MW and yearly power output of 10 GWh, equal to 0.05 percent of our developable capacity. The main reason for the small scale of tidal power development is the large investments required. In the area of wave energy utilization, India, Indonesia, and Japan now have commercial wave energy power stations in operation. The islands along China's coast have also obtained excellent technical economics benefits from wave energy utilization. China has rich marine resources and their rational development require unified consideration and arrangements in technical economics.

5. Biomass energy: The total amount of organic matter in the world which could be used for extraction of methanol and ethanol amounts to 160 billion tons, including 100 billion tons on continents and 60 billion tons in the sea. The ways to utilize biomass energy are: 1) Planting "energy forests" such as highly-sweet fruits, sugarcane, and so on. These plants convert solar energy into plant chemical energy which can be used to extract liquid fuels (ethanol, etc.) for further utilization. 2) Gasification of agricultural and forestry wastes. The United States and India have developed the utilization of waste timber for power generation. China's Northwest Agricultural University has developed a technology to compress and mold waste straw and wood chips that gives them a higher molded material ratio and fuel value than coal that is now being commercialized. 3) Animal chemical energy utilization. Clean biogas (primarily CH_4) generated through anaerobic fermentation of animal waste can be used for motive power or generating electricity. China now has over 5 million household biogas pits which generate 1.2 billion cubic meters of biogas each year. Biogas fermentation technology falls within the scope of biotechnology and is a high technology, but our failure to be concerned with research and key technology for a long period (including fermentation principles and techniques) has made progress difficult and affected its utilization on a large scale. The organic waste liquid discharged by China's urban industries has a high chemically depleted oxygen and organically depleted oxygen content, so it can be used as urban biogas and help reduce environmental pollution. Industry groups should be formed for biogas development to engage in research and develop food—energy resource—ecology chains and improve the environment in which mankind exists.

6. Nuclear power: The world had 434 reactors used for nuclear power generation in 1989 with a power of 317.91GW. The United States has 110 nuclear power reactors, first place in the world. Nuclear power accounts for the largest proportion of power generation in France at 74.6 percent. China has imported two 900MW pressurized-water reactors [PWR] for its Daya Bay nuclear power plant in Guangdong. Testing of the first generator is expected to begin in 1991 and it will start operating and generate power in 1992. The second phase project will go into operation in 1993. At Zhejiang's Qinshan nuclear power plant designed by China herself, 300MW may be connected to the grid and generate power in 1991. Construction on the 600MW second phase is being speeded up and research on the third phase project is now being implemented. The investment costs and ecological benefits of developing nuclear power are superior to conventional power plants. By the end of this century, nuclear power will still not be able to account for a substantial proportion in China. The reason is that we lack development capital.

7. Hydrogen energy: As a high-tech energy resource, hydrogen energy is now receiving attention in the developed nations. Germany leads the world in hydrogen energy transmission technology. Canada has already built a plant with a daily liquefaction capacity of 10 tons. The Soviet Union has successfully used liquid hydrogen in flight tests of its Tupolev-155 airplanes. China's Ministry of Metallurgical Industry Baotou Metallurgy Institute developed metallic hydrogen storage materials in 1981 and used them in trial operation of automobiles. If an inexpensive new hydrogen making technology for extracting hydrogen from water can be adopted, inexhaustible hydrogen energy could be widely used. For this reason, the China Energy Resource Research Society

Hydrogen Energy Commission was established in September 1986 and it has begun organized and planned undertaking of research work.

II. Strategic Ideas and Countermeasures for Developing New Energy Resources in China

Gradual replacement of conventional energy resources by new energy resources centered on high technology is an inevitable historical development trend. Up to the end of this century, China's development of new energy resources will be slanted toward rural areas. In the early part of the next century, the proportions of new energy resources and conventional energy resources will be in a confrontational state in China's cities and the types of energy resources used in each region will depend on differences in regional energy resource distributions. For different categories of new energy resources, uneven development levels of new technology for their research and development will determine that there should be differential treatment when formulating development strategies for them.

China's development of solar power will be done in two steps. The first step is development of hot water heaters, dryers, solar stoves, and so on which directly utilize solar energy to expand commodity markets and try to earn more foreign exchange. The second step is development of solar energy for motive power and power generation to make obvious achievements during the early part of the next century. China's development of wind power up through the end of this century will combine perfection of small wind-powered generators for household use with active development of medium-sized and large wind-powered generators, planning good wind fields, implementing connection of wind-powered generators to grids, and improving economic results. To promote the commercialization of wind-powered generators, we must, one, continually improve the product mix, ensure quality, and reduce costs, and, two, promote competition among producing plants and expand domestic and foreign markets. Projections indicate that in the early part of the next century, there will be a rather substantial increase in the proportion of wind power in China. China's development of geothermal energy will involve, one, striving to popularize direct utilization of geothermal energy at locations which have geothermal energy by the end of this century, and, two, developing geothermal power plants in regions with abundant geothermal energy resources and sufficient finances. We expect to see the beginning in the early part of the next century. As for China's development of marine energy in the future, on the one hand we will encourage local areas to raise capital to develop small tidal power stations and on the other hand we will expand the scope of experiments in using wave energy to generate electricity to provide sources of electricity for illumination and motive power on islands. Arrangements may be made to develop large-scale tidal power stations during the early part of the next century, and the task at present is to do good design preparation work. As for development of other marine energy resources, the main thing now is doing good theoretical research and technical reserve work while waiting for conditions to mature to undertake major projects. For China's development of biomass energy, biogas is one route that can provide quick economic, social, and ecological benefits. Its development direction is to combine development of large, medium, and small scales. Output is expected to reach 2 to 3 billion cubic meters or even higher by the end of this century. China is now the world leader in developing biogas and the key to future work is R&D on biogas bioengineering to move it up to an even higher stage and strive to form a relatively large-scale industry by the early part of the next century. China's development of nuclear energy (mainly nuclear power) will include the two aspects of installed generating capacity and selection of reactor types. Because nuclear power is a capital and technology-intensive industry, with a unit investment of about $4,000 per kW of installed capacity, the high investment cost is the main factor restricting development of nuclear power in China. By the end of this century, China's nuclear power installed generating capacity will reach 3,000MW, but this will only serve as an embellishment. China's selection of PWR as the reactor type was correct and future choices of reactor types should track world developments in nuclear power technology and explore new models for developing nuclear power in China. China's hydrogen energy research is now in the initial stages and should be put on the correct track of applied research by the end of this century and strive to be able to open up a new stage during the early part of the next century. This requires careful planning and industrial policy support.

To deal with these strategic ideas for developing new energy resources, we should adopt the following countermeasures:

1. Given China's widely-distributed new energy resources, varying degrees of R&D for each type of new energy resource, and regional differences in economic development levels, there will also be differences in the direction of new energy resource development. A single model cannot be used to plan the structure of new energy resources for each region through the end of this century. We should adapt to local areas and adapt to conditions. There must be distinctions between south China and north China, between the coast and the interior, between cities and rural areas, and between regions with dense populations and those with sparse populations to adopt countermeasures in a targeted manner and continually carry out macro readjustment and control rational allocation.

2. The state's "863" plan has already included research on two types of high technology, new nuclear power reactor types and magnetohydrodynamic power generation. Actually, using solar power to generate electricity and developing hydrogen energy, realms which have received attention in many developing countries, also have real practical significance for development in China. China has a vast territory and many regions with a scattered and sparse population where energy resource

coverage rates are low. Developing these new energy resources could satisfy 80 percent of the demand for energy of rural areas and pastoral regions, so it is a choice which conforms to China's national conditions. Therefore, including them in research plans and tracking the leading edge of high technology in the world offer extremely substantial development prospects for them and should receive attention.

3. Developing all types of new energy resources involves both technical issues and economic issues. It is easy for technical problems to receive the attention of relevant departments, but technical development requires economic support because it will fail without economic guarantees. Thus, beginning with the long-term interests of energy resource development, we should give combined consideration to technology and economics when making policy and make more people understand that specific economic inputs today are for the purpose of obtaining even greater economic benefits tomorrow and thereby make them show concern for inputs. New energy resource development should become development for technical and economic benefits to form operational mechanisms which integrate development, production, and utilization and accelerate the pace of industrialization of new energy resource development and utilization.

4. To open up new energy resource product markets, new energy resource development should undergo a transition and conversion from a production type to an administrative type. Energy resource policy is a major national policy. Support, preferential raw materials prices, tax reductions and exemptions during development periods, and so on have been stipulated for quite some time, and policy preference guarantees have also been provided for readjustment of its structure (development of new energy resources) to increase the returns to investments in new energy resources. From the enterprise perspective, new energy resource products must be standardized, systematized, and generalized, product quality must be guaranteed, they must facilitate the pursuit of perfection of maintenance and inspection measures, they must be attractive and inexpensive, and they must satisfy consumer demand and desires.

5. New energy resources require new management systems and operational mechanisms. In China's energy resource management, regardless of whether product development is best or project construction is best, we have always lagged behind the industrially developed nations for quite some time. This is manifested as low production worker levels, poor management personnel quality, unclear economic benefits, major consumption in all links of the operation system, and low full-staff labor productivity. During our years of reform and opening up, we have been concerned with reform of the management system and the situation has improved. Now, new energy resources have begun entering commodity markets, but we still have a rather long way to go in development. Management of new energy resources should borrow from foreign management experiences and absorb domestic management experiences for conventional energy resources to establish entirely new management systems and operational mechanisms, perfect the service system, and perfect technical networks to increase economic benefits and labor productivity.

6. In developing various new energy resources, we should be concerned with commercialization and industrialization of new energy resource products as quickly as possible. Products are developed for consumers and only become commodities when there are consumers. New energy resource development must be concerned with optimum technical economics benefits and optimum benefits are achieved through industrialization. Commercialization and industrialization are essential conditions for achieving vitality in new energy resource development. Only through commercialization and industrialization can they be converted into benefits, can costs be recovered, and can the capital conditions be provided for redevelopment.

7. To adapt to the development of new energy resources, we should train skilled personnel in a targeted manner and propagandize and popularize knowledge of new energy resources. All institutions of higher and secondary education should provide leading training for a group of advanced and mid- level technical personnel and administrative personnel. We should adopt correspondence-type training or rotation training for cadres on the job. We should foster the role of societies, associations, and other academic groups in organizing study classes, holding discussion meetings for popularizing knowledge, and scholarly exchanges. All sorts of scholarly publications and popular publications should provide appropriate introductions to knowledge about new energy resources and middle and lower school educators should add new energy resource knowledge contents to lay a social foundation for knowledge about new energy resources.

8. Reinforce international cooperation and exchanges in the energy resource S&T area. At present, energy resources are a major issue of international concern and development of new energy resources is attracting attention in many countries. China's development and utilization of new energy resources on the one hand requires importing advanced technology and equipment from foreign countries and doing good absorption, digesting, and innovation work to lay a technical foundation for China's new energy resources, and on the other hand requires seizing opportunities to open up international markets for China's mature new energy resource technology (such as solar hot water heaters, solar stoves, biogas technology, and so on). Many developing nations have expressed an interest in China's achievements in this area, so the conditions already exist to export our products and technology. In our future international cooperation and exchanges, we should also combine the two levels of mutual visits by scholars and mutual assignment of students for study abroad to adapt to the many technical requirements and administrative requirements of domestic research.

Forecasts indicate that by the end of this century, the proportion of new energy resources in China will account for 5 to 10 percent of gross output of primary energy resources in China. During the first 20 to 30 years of the next century, this proportion will increase to 20 to 30 percent. Relevant departments of the state should be concerned with this development trend, adroitly guide their actions according to circumstances, and accelerate the pace of readjustment and reform of China's energy resource structure.

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